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AN EARLY PHYSICAL CHEMIST—M. W. LOMONOSSOFF[1]

AT the present day, it seldom happens that due credit is not given to each chemist for any new facts which he may add to the sum of chemical knowledge and, conversely, it is usually an easy matter to attach to any given fact the name of the investigator who first discovered it. For reasons which, in part, at least, are obvious, these conditions are not always so easy to fulfil in the case of the fathers of the science. It is certain, at all events, that frequently recognition has here been long delayed and, even where the most fundamental facts are concerned, the determination of the parentage has had repeatedly to be revised.

At the very start, there is difficulty in settling what constitutes *discovery*. Scheele's preparation of oxygen undoubtedly took place a year or two before Priestley's, but his publication of the results was delayed until three years after Priestley's, and priority in discovery is generally held to require priority in publication.

Again, Paracelsus obtained what is now known as hydrogen by the action of iron filings upon vinegar, but Cavendish defined the substance by its properties, and so the discovery dates from 1766. Liebig prepared bromine, but set the sample aside, believing it to be a chloride of iodine, and Balard, who prepared the substance later, and recognized it to be a new halogen, became the discoverer. Similarly, a

[1] Presidential address, delivered before the American Chemical Society at Washington, December 28, 1911.

hundred years before Priestley's time, Borch (1678) prepared what is now known as oxygen in large quantities by heating saltpeter, but he failed to ascertain any of its properties; and again, forty-five years before Priestley's experiment, Hales collected the gas from the same source over water (the first record of any attempt to collect a gas in this way) and obtained, by measurement, 97 per cent. of the theoretical amount. But Priestley, on August 1, 1774, liberated it from mercuric oxide. A lighted candle happened to be standing before him at the moment. By pure chance, as he himself says, and without any particular reason which he could afterwards recall, he immersed the candle in the gas and found that the combustion was unusually brilliant! He thus ascertained one distinct property of the substance and became the discoverer of oxygen. True, he thought at first that it was a compound of nitrous acid, earth and phlogiston, and only in the light of the views of Lavoisier and others, and after long delay, did he accept in 1786 the conclusion that it was an elementary substance. It may be noted that, although Scheele was a better experimenter, his idea of the nature of oxygen was not much clearer. He thought that fire-air (oxygen) united with phlogiston to give heat, and that the last was a compound of the first two. Evidently, in those days, isolating the substance, and defining one or two of its properties, together conferred discoverer's rights, no matter how grotesquely the nature of the substance was misunderstood.

I say "in those days," for Curie made several compounds of radium, establishing their relations to one another, and is justly held to be the "discoverer of radium," although no isolation of the element was attempted. Now that the science has developed, isolation can be dispensed with, and, in point of fact, was omitted in most of the exploratory work amongst the rare metals. If this principle could have been applicable in earlier days, several of the decisions of chemical history might have been reversed. A hundred years before Priestley's time, Mayow (1669) had shown by conclusive experiments that atmospheric air was made up of two components, of which the active one formed twenty-five per cent. of the whole. In measuring the amount, he employed the same reaction subsequently used by Priestley, namely, removal of the oxygen by the introduction of nitric oxide and absorption of the product in water. But whereas Priestley was thereby estimating the "goodness" of the air, and had no idea that he was dealing with a mixture, Mayow was perfectly clear as to the interpretation of the results. The latter demonstrated that the same component was removed in combustion, by rusting metals, by the alcohol in vinegar-making and by the blood in respiration. He traced the animal heat of the body to a process analogous to that which heated the mass when marcasite rusted in the air. He identified this active component of the air as a constituent of saltpeter, and particularly of the acid part of this substance, and (like Lavoisier more than a century later) held that it was contained in all acids. Finally, he considered it to be an element, in the modern sense of the word. Unfortunately circumstances conspired to relegate to obscurity all his wonderful work and magnificently clear reasoning. Mayow was a young physician, and the divergent view-point of Boyle, as an older man and an eminent philosopher, received more attention. Again, the logical conclusiveness of Mayow's proof of the existence of oxygen as a distinct substance, was entirely over the heads of his contemporaries, and his way of thinking quite out of

harmony with theirs. In this point of view, he came a century and a half too soon. Such a proof, if offered at the present day, would be accepted as conclusive. The final isolation of the element would now be considered a matter of mere routine, that could be assigned to a beginner in research, as the basis of his dissertation for the degree of doctor of philosophy. Finally, the clouds of the phlogistic theory soon began to darken the sky of the science, and before long the spread of this remarkable notion, diligently fostered by Stahl, who had been born nine years before the appearance of Mayow's work, enveloped chemistry and the whole chemical world in an impenetrable fog. Since the believers in phlogiston started always with one absurd idea as the major premise, namely, that, in combustion and oxidation, some kind of matter *left* the burning or rusting material, the more rigorous the logic of the subsequent steps in the reasoning, the more certain was the attainment of uniformly false conclusions. The inveterate phlogistian, and everybody down to the time of Lavoisier, not excluding Priestley and Scheele, was forthwith an inveterate phlogistian, saw in simple, almost modern modes of thought, like those of Mayow, only the sheerest nonsense. If we all stood habitually upon our heads, naturally any one caught persisting in a tendency to view the universe in the normal way would be instantly adjudged insane. For these various reasons, Mayow's work was first neglected and then forgotten.

The story of Mayow suggests some additional conditions which determine the recognition of a discoverer, and the acceptance of his discovery. How often in the history of science has a dominating but conservative personality diverted attention from younger or less prominent men, or at the least, by hostile criticism, delayed the acceptance of their ideas. The discoverer who occupies a conspicuous social position is, often, more readily detected. Then again, for the dealing of strict justice, the consequences may be almost as unfortunate when the discoverer is a century ahead of his time, like Mayow, as when he is three years late, like Scheele. And, finally, an intellectual plague like the phlogistic theory may be epidemic. An infection runs until a milder generation of the infecting organism is gradually evolved, or until the presence of the organism results in physiological changes which automatically give rise to substances that destroy it. Lavoisier was fortunate in arriving upon the scene when the disease was ready to loosen its hold. It was not that his fundamental experiments, upon the subject of air and oxygen, were new—the same conclusions could have been reached by putting together the work of his predecessors and contemporaries. It was largely because of his personality, and because he arrived at the psychological moment.

I have prefaced my address in this way, in order to furnish a setting for its subject. He lived from 1711 to 1765. He thus was educated, did his life-work, and died in the most virulent period of the phlogistic epidemic. Heat, light and weight were then forms of matter, yet, when he notices them at all, he combats these views, and makes experiments to disprove them. In a day when the jargon of the phlogistian was the only language of polite intercourse amongst chemists, he speaks and writes the language of modern chemistry—of the most modern chemistry, for he was a physical chemist. Needless to say, he lived at a time far removed from the psychological moment for a man holding such a viewpoint. Naturally, credit for his discoveries, and they were many, has all been distributed amongst others. It is quite

likely that some of you have never happened to hear his name—the name of Michael Wassiliewitsch Lomonossoff.

Even in Russia, although his work in literary and linguistic lines, his success as a man of affairs and his investigations as a geographer and a meteorologist had won for him enduring fame, the fact that he was primarily a chemist had been completely forgotten. It was Menschutkin[2] who, a few years ago, rediscovered him as a chemist, reprinted in Russian his scattered memoirs and collected all that could be found of his manuscripts, letters and laboratory note-books.

Although trained—chiefly in Germany—by, and along with, men who ardently supported the current views, he seems with astonishing ease to have thrown off the prejudices of his contemporaries, and to have achieved a perfectly independent view-point of his own. At that time, the emission of light-matter explained the phenomena of light. Largely through the enormous influence of Newton's selection of the emission theory in preference to the wave theory (first developed by Huygens in 1690), this remained the accepted explanation until after a hard struggle against the influence of Laplace (1817) and others, who were unconvinced, with the explanation of the phenomenon of polarization by Fresnel, the ether-wave theory finally triumphed. But Lomonossoff discusses (1753–56) the possible motions of ether—progressive, rotatory and wave-like—identifies the last as the basis of light, and goes in great detail into the nature of ether, and the properties of light-waves and the mode of their propagation.

In Lomonossoff's day, heat was also a form of matter. The classical experiment of Rumford was made (1798) thirty years after his death. But, so strong was the prejudice, that, even then, the proof (by quantitative experiments) that heat could be generated without limit from friction, under conditions such that the addition of any substance or form of matter was impossible, did not carry conviction. Lavoisier believed (with some hesitation, it is true) in an imponderable *matière de chaleur*. It was not until after the work of Mayer (1842), who was at first persecuted for his views, and especially after the demonstration by Joule (1855–60) that heat and work were mutually and quantitatively inter-convertible, that the theory that heat was matter finally disappeared. Yet Lomonossoff, more than a century earlier (1744–47), in a paper on "The causes of Heat and Cold," discusses in detail the experimental evidence that motion is a source of heat, and that molecular motions are caused by heating. Radiant heat, of which then little was known, was transmitted by motions of the ether, which he believed to be of the rotatory variety. In all his papers, heat is always a mode of molecular motion. The paper named was the subject of vigorous discussion, particularly in Germany, and, after the views contained in it had been sufficiently abused, they were consigned to oblivion.

The kinetic-molecular theory of gases used to be attributed to Krönig (1856) and Clausius (1857). But Lord Rayleigh discovered in the archives of the Royal Society a very complete form of it, contributed by Waterston in 1845. The state of public opinion among physicists, even then, a century after Lomonossoff's work, may be judged from the fact that the committee of the society considered the content of the paper to be nonsensical, and refused to permit its public presentation. Lomo-

[2] "M. W. Lomonossoff, as a Physical Chemist," St. Petersburg, 1904. See also an article by Menschutkin, *Annalen der Naturphilosophie*, **4**, 203.

nossoff's paper, read before the Academy of St. Petersburg in 1744, nearly suffered the same fate, for it was withheld from publication for three years. Starting with the view of Daniel Bernoulli (1738), to the effect that the pressure of gases was due to the impacts of their particles, Lomonossoff proceeded to develop ideas very much like those now held. According to him, for example, a rise in temperature caused increased motion of the particles, and resulted therefore in increased pressure. His theory differs from ours mainly in the fact that rotatory motions played a large part, and that the molecules had rough surfaces. Incidentally he points out that there is no limit to the possible amount of motion, and therefore no maximum of temperature, but that there is a minimum of motion, when the latter becomes zero, and there must therefore be a minimum of temperature. In a later paper (1750) he proves by his hypothesis that the pressure *should* be, as it was then known to be, inversely proportional to the volume. And he goes further, for, with surprising insight, he shows that, with increasing pressure, this relation will no longer hold, since the volumes of the particles themselves are not diminished. The reputed discoverer of this consequence of the theory is Dupré (who was thus anticipated by 115 years), and in 1873 Van der Waals finally put the same fact into definite form.

In all this, it must not be supposed that Lomonossoff was simply a reasoner, much less a speculator. The discussion is loaded with a wealth of experimental facts, many of them ascertained by himself. It is especially noteworthy, also, that his experiments, almost without exception, were quantitative. When we remember that the balance is a stubborn instrument, and that its evidence always went contrary to the conclusions of those who pinned their faith to heat-matter and phlogiston, we perceive how completely his habits of work and attitude of mind were out of harmony with those of his contemporaries, and how startlingly independent were his modern ways of experimenting and reasoning.

Before turning to the part of his work that was more especially of a chemical and physico-chemical nature, a few words about his career may be of interest. He was born of peasant parents—Russian peasant parents of the early eighteenth century—about the year 1711, and in a village forty-five miles from Archangel. Opportunities for education there were none. Finally, at the age of nineteen, he reversed the procedure of the typical boy, and ran away, to go to school. At 24, he left the school in Moscow to attend the lectures of the professors in the Academy of Sciences in St. Petersburg. At twenty-five he was sent on a traveling scholarship to Marburg, where he studied chemistry under Wolff. After three years, he went to Freiberg, and two years later he returned to St. Petersburg. In both places, when he moved, the academy had to pay the debts that he had incurred! Upon his return home, he became adjunct professor at a salary of $900, but the academy, being poor in money, paid its professors largely by gifts of copies of its publications, a sort of product for which there is an almost infinitesimally slow market. A year later, we find him in the university, lecturing in Latin on chemistry, geography and the Russian language. Lecturing in Latin upon the Russian language to Russian students! Such simple, blind devotion to a tradition surprises us—even when it occurs in a university. His active experimental work as a chemist began in 1744, when he was thirty-three years of age, and in 1845 he was appointed to the professorship of chemistry.

After three years of planning, a chemical laboratory was built, and on the 12th of October, 1748, it was opened. The building, a modest one, measured 45 × 36 feet, and was divided into a large room for work and two small rooms for lectures and storage. It cost $4,000, and about $1,800 additional was spent on furnaces and other equipment. Thus, in providing a place for laboratory instruction, as well as for research in chemistry, Lomonossoff was fifty years ahead of Hope in Glasgow and seventy-five years ahead of Liebig.

Lomonossoff's period of greatest chemical activity was compressed into the nine years that followed the opening of the laboratory, for in 1757 he resigned his chair. During the remaining eight years of his life the numerous activities of a public man, and a diversion of his interests into other scientific lines, interfered with chemical work.

Up to the end of the eighteenth century, there was utter confusion of thought in regard to the composition of materials. In considering the make-up of a specimen, and the changes occurring during an experiment, heat-matter, light-matter and weight-matter, as well as phlogiston, were taken into account. As we have seen, even Scheele interpreted the phenomena he observed upon the theory that heat was an oxide of phlogiston! The composition was often stated in terms of salt, sulphur and mercury, whether there was evidence of their presence or not. The "elements" of Aristotle, and cognate ideas, were used in describing and in thinking about chemical phenomena. In consequence, Priestley thought he had a method of measuring the "goodness" of air—as a quality—when in point of fact he was measuring the amount of oxygen—as a component. With the basal conceptions thus in a state of utter chaos, it is no wonder that the simplest chemical situations were wholly misunderstood, and that the simplest experimental results, being described in terms of non-existent entities, and thought of in terms of non-existent relations, failed of their object. It was Lavoisier who received the credit for setting our ideas permanently in order, by his emphasis upon the significance of the evidence of the balance, and by his setting forth clearly the idea of chemical compounds and their component elementary substances, and by giving a classified list of the latter.

The chemical reformation might have come half a century sooner, however, if Lomonossoff's papers had been more widely known. As we have seen, to him heat and light were not forms of matter and phlogiston had no existence. His forms of matter were the same as ours, and his ideas of chemical composition, what it included and what it excluded, the same as ours. In his "Elements of Mathematical Chemistry"[3] (1741), and in a later paper "On the Imperceptible Physical Particles, which Compose Natural Materials, and in which is to be found a Sufficient Basis for the Specific Properties" (1742–43), he gives a singularly clear and minute discussion of the whole subject. He distinguishes between the attributes (weight, volume, etc.) of a body or specimen, and the specific properties which characterize a substance. In modern fashion, he defines the "imperceptible particles" or "corpuscles" (molecules), which are portions of a substance, and the "physical monads" or "elements" (atoms) which are not decomposed in chemical change. He draws clearly and in detail the distinction between simple and compound substances, the latter of which contains the "prin-

[3] This and parts of others of his papers are published, in German translation, in Ostwald's *Klassiker*, 178.

cipia'' (elementary forms of matter) in chemical combination. The explanations are in experimental, and not obscure, theoretical terms.

In the paper on ''Heat and Cold'' (1744–47) he refers to Boyle's experiment, in which lead was sealed up in a retort and heated, when the lead and calx, upon removal, were found to have increased in weight. According to Boyle, this result showed that the heat, which alone could enter through the glass, had weight. Lamonossoff, of course, will not accept this conclusion and points out that the increase in weight of metals when heated in air must be due to union with material from the air, just as their increase in weight when placed in the flame of burning sulphur is due to union with ''acid'' from the sulphur. Later, in 1756, he repeats Boyle's experiment, and finds that, until the retort is opened and air rushes in, no increase in weight is observable. He thus performed one of Lavoisier's most fundamental and convincing experiments eighteen years in advance, and interpreted it correctly. It is apparent that Lomonossoff's sound views were based upon many quantitative experiments on combustion, although the laboratory note-books containing the details have not yet been found.

But, if Lomonossoff anticipated Lavoisier in his work upon the chemical relations of the forms of matter, he went far beyond Lavoisier in his views in regard to the uses of mathematics and physics in chemistry, and, in this direction, anticipated many of the points of view of the later nineteenth century. Lomonossoff's unfinished treatise, ''The Elements of Mathematical Chemistry'' (1741), of which only a fragment survives, deals with a conception which, in all his writings, he never ceased to urge, namely, the value of mathematical methods in chemistry. Ten years later, in an ''Address on the Uses of Chemistry'' (1751), he speaks as follows:

> If chemistry unites to solid form the separated and scattered particles in a solution, and brings forth various formations, it must be that she relies upon the strictest and most highly developed Geometry. . . . If she changes solids into liquids and liquids into solids, and divides and unites them to give various substances, it must be that she seeks counsel of the most exact and ingenious Mechanics. If chemistry, by union of different substances, gives rise to different colors, she needs the help of the most profound Optics. . . . If the knowledge-seeking, tireless investigator [in response to this] will only survey her through geometry, measure her forces by mechanics, and consider her through the science of optics, he will probably reach his desired goal.

In this we seem to see at least an adumbration of chemical crystallography, and of chemical dynamics and statics. He continues:

> Why have investigators had no success? I answer that for this a very skillful chemist is needed, who is at the same time a mathematician.

Has not the recent development of the science been along the precise lines which he thus lays down?

Lomonossoff's applications of geometry in ''De Nitro'' (1749), a comprehensive study of saltpeter, will illustrate his own attempts to use mathematical methods. He discusses at length the crystalline form of the substance and proceeds to develop a theory of crystalline structure. In saltpeter, the prismatic form can be accounted for by an arrangement of round particles, in such a way that lines drawn through their centers always form equilateral triangles. In other substances, the arrangement is different, so that, for example, in common salt, the lines through the particles may form squares. As usual, he paid the penalty of being far ahead of his time. Yet he had anticipated by a century the essential conceptions of Bravais (1850), whose mathematical study of all

possible space nets, and their relation to existing crystalline forms, coming at a more favorable time, led almost immediately to the completion of development along this line by Sohncke (1867).

In the same address, he continues:

> [The chemist] is surely unapt, who has made a mass of experiments, but, in the effort to secure quickly accessible products, hastens to the attainment of this as his sole goal; he overlooks those phenomena and changes occurring in his operations which might lead to the explanation of nature's secrets.

If this viewpoint, with its contempt for purely preparative chemistry, had been as prominent in the creed of all the chemists of the century and a half since Lamonossoff's time, as it was in his own, instead of being until recently the ideal of only a few scattered chemists, what a different science ours would have been. How many papers, signed by notable names, might have offered something of substantial scientific value, in place of a mass of new entries for the indexes of Beilstein and Dammer. In the preface to his treatise on saltpeter, he develops the same idea:

> Since as yet no general physical bases for explaining the formation and composition of chemical substances exist, and since few physical experiments have been applied in chemistry so as to lead to the desired results, it may seem difficult, but we believe it to be possible, scientifically to describe the greater part of chemistry in terms of the interrelations of its own principles and their connections with those of physics. We do not doubt that, after the union of chemical with physical truths, we shall be able more successfully to understand the inner nature of substances.

Be it understood, these generalities are only summaries of the plans of study which, in his experimental work and in his papers, he attempts in thoroughgoing fashion to put into practise. Uttered as they were in the heart of the period of phlogiston, of heat-matter, and of confused experimentation and reasoning, they have an uncanny sound, and almost terrify us with their supernatural prescience. How long have we had to await the psychological moment for the general application of these ideas! Had only the times been ripe; had only the atmosphere been healthy for the propagation of such ideas as his, instead of being virulently poisonous to them, our science might easily, by now, have been a hundred years ahead of its present position, and we might to-day have been listening to papers which, as it is, will not be read for a century. If Dante's *Divina Commedia* were to be revised by a chemist and brought up to date, the chief change he would make would be the provision of some horrible and revolting torment, calculated to give Stahl his just deserts.

The occasion is not a suitable one for going in detail into the mass of (for that time) novel and suggestive quantitative physico-chemical experiments which occupied Lomonossoff from 1752 to 1756. The extent of his plans—only partially fulfilled—may be judged from his "Dromus ad veram chymiam physicam" (Course in true Physical Chemistry, 1752), of which a considerable part was written, and much survives. In the introduction he mentions, amongst other aims of physical chemistry, this:

> One must determine the specific properties of every substance as exactly as possible, in order that, after the composition has been ascertained by chemical operations, one may judge whether, and to what extent, each property is altered by changing a given constituent.

No statement of one of the purposes of physical chemistry could be clearer.

In the experimental part of the book, salt solutions receive much attention, and many modern problems may be recognized, such as measurement of exact solubilities at various temperatures, volume changes in solutions, capillary phenomena, action

of electricity upon solutions and relative deliquescent tendencies of salts. There is, of course, a good deal about crystallography. In the absence of the laboratory note-books, only parts of some of the tabulated results have been found. One set of experiments, chiefly with common salt, led to the conclusion that the freezing points of solutions are lower in proportion to the amount of the dissolved body. Even the most insignificant experiments were carried out quantitatively.

In Lomonossoff's laboratory, a good deal of special apparatus was devised. Measurements of the coefficient of expansion of air had been made, and a value (recalculated to 1° C.) of 0.003 (in place of 0.00367) was found. This led to the construction of an air-thermometer for measuring low temperatures. Incidentally, he reformed the Delisle scale of temperatures, which ran downwards from 0° at the boiling point of water to 150° at the freezing point, by simply inverting it (0° L. = 0° C., 150° L. = 100° C.). A thermostat for ice and water was employed in some experiments, and instruments for the study of oceanography, devised by him, came afterwards into general use. One of the most extensive pieces of work done in his laboratory was a study of colored glasses and mosaics, the results of which led to the establishment of a factory, still in successful operation, near St. Petersburg.

The achievements of Lamonossoff outside of chemistry were as remarkable as those within that science. He wrote a treatise on metallurgy, made investigations in meteorology and especially atmospheric electricity, in geology, and in mineralogy, and he assisted in the equipment of expeditions for geographical exploration. He observed the transit of Venus of 1761, and drew from his observations the conclusion that the planet had an atmosphere "similar to, and perhaps greater than that of the earth," a discovery generally attributed to Schröter and Herschel (1791).

No undertaking that required courage and originality was outside the comprehensive sphere of his interests. He was the first to attempt to apply modern forms to the writing of poetry in the Russian language, and was the author of odes, poems, and even of tragedies to be performed in the Court Theater. He prepared a Russian grammar and a treatise on rhetoric. He devised a vocabulary for expressing scientific conceptions, and his terms are those now in use in Russia. As the most prominent Russian man of science of his time, public affairs claimed much of his strength. Taking him all in all, the rediscovery of Lomonossoff has added at once a chemist of the first magnitude and a personality of marvelous force and range to the limited gallery of the world's very greatest men.

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THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

THE CAUSE OF HIGH PRICES[1]

IF the student of present-day affairs should classify the reasons for existing discontent, he would certainly give to the high cost of living a position in the front rank. Dominant political parties, ruling ministries, national policies and local conditions are indiscriminately blamed, yet the phenomenon of high prices is manifest among all progressive nations and in a degree throughout the whole world. It is in evidence in all countries regardless of tariff policy and monetary standards. It is also

[1] Address of the vice-president and chairman of Section I, Washington, 1911.

apparent under all forms of government. If there is any one class of countries in which the phenomenon attracts less attention it is in those which are least advanced in civilization. Obviously many of the causes to which this general rise in prices has been ascribed must be fallacious because of its universal prevalence.

In explaining the causes it is essential to recognize three fundamental facts, very obvious in their nature, but not so readily understood in their bearing upon the present situation:

1. The rapid progress made by leading nations in modern times.

2. The striking inequality of this progress in different branches of human endeavor.

3. The inevitable tendencies in every progressive era to overaction in enterprise and to extravagance and waste in expenditure.

The second and third facts are subordinate or incidental to the first and closely associated with each other. Let us explain the effect of each in its order.

1. Notwithstanding long periods of inertia and even of retrogression, the dominant note in the history of the race has been that of progress; this has been especially true in the last 100 years. Scientific progress has always been in the van, followed by material, intellectual and political progress. Science has given to mankind a constantly increasing control over nature. Inventions and discoveries have greatly multiplied the supply of useful articles adapted to satisfy human wants. As a result, the convenience and luxuries of one generation are regarded as necessaries in the next. One marked effect of this progress is the alleviation of the struggle for existence, with the resulting leisure or opportunity to acquire greater skill and to discover new methods of production. The requirement of less effort for obtaining the necessaries of life gives a wider scope to human enterprise and makes it possible to multiply the achievements which contribute to the betterment of the race.

Nothing is more apparent than that the average per capita consumption is constantly increasing, not merely in essential food products, but in a variety of useful articles which are now available for more general use. Some tables prepared by the late Professor Richmond Mayo-Smith set forth clearly the increased consumption of divers articles in several countries of Europe in periods of 20 to 25 years:

ANNUAL CONSUMPTION PER CAPITA IN DIFFERENT COUNTRIES IN DIFFERENT YEARS

Article and country	Date	Date	Increase Per Cent.
Meat, France	25.9 kilos	33 kilos	27.41
	1868	1890	
Meat, England	100.5 kilos	124.5 kilos	23.88
	1871-75	1891-95	
Tea, Germany	.02 kilo	.05 kilo	150.00
Petroleum, Germany	3.75 kilos	14.82 kilos	295.2
	1871	1896	
Flour, United Kingdom.	150 lbs.	257 lbs.	71.33
Tea, United Kingdom...	3.91 lbs.	5.77 lbs.	47.57
Eggs, United Kingdom.	12.6	40	217.46
Butter and margarine...	4.7 lbs.	11.1 lbs.	136.17
Cocoa	.23 lb.	.62 lb.	169.56
Bacon and ham	3.4 lbs.	15.9 lbs.	367.64
Refined sugar	5.28 lbs.	41.53 lbs.	686.55

It may be noted that modern means of communication, the ready transmission of news and the increasing scope of industrial and commercial operations have brought about a solidarity of interest among nations and rendered it easy to obtain by international trade useful articles even from the remotest parts of the earth. These same forces have promoted political progress, the assertion of popular rights and a greater equality of opportunity. One effect of this has been that wealth and the consequent increase of average consumption are no longer limited to a few.

The development of a more peaceful disposition among nations has caused a great increase in both production and consumption. Human effort has been less occupied with warfare and more with the development and utilization of the world's resources. All these factors make possible a rising standard of living which increases prices, unless there is equal progress in the various branches of production.

2. Progress, however, has been notably unequal in the different branches of endeavor which supply human wants. It is necessary to keep in mind the difference between a rise in the price of certain classes of products and a general rise in the price level, to which reference will be made later. There is a substantial distinction between these two phenomena. New methods in industry and commerce are revolutionizing the means for supplying human wants, but their effect is far more helpful in some categories of products than in others. Whether this be the result of natural conditions or limitations upon our knowledge is not pertinent to this inquiry. The fact is obvious. Throughout all periods, notwithstanding changes in fashion and taste, there has existed a demand amounting to a necessity for certain essential products, such as food, clothing and shelter. It is evident that science, working through inventions and improved methods, has not accomplished the same results in agriculture, especially in producing food supplies, as in manufacture. The revolution in industrial methods and in the utilization of capital in large scale operations has not been accompanied by equal progress on the farm. Very considerable progress has been made, it is true, in carrying agricultural products to the market and in preserving them for use, but these pertain to transportation and to the middleman rather than to the original producer. Accordingly, as we should expect, the prices of farm products have risen much more rapidly than the prices of manufactured articles. In a very valuable report of the Chief of the Bureau of Statistics for the Department of Agriculture for the year 1910, a comparison is made between the increase in the prices of articles purchased by farmers during the ten years from 1899 to 1909 and the increase in the value per acre of that which the farmers sell. For the articles purchased the average increase was 12.1 per cent., while the average rate of increase in the value per acre of that which the farmer sells was 72.7 per cent., or six times as much. The comparison is made even more emphatic when it is noted that among the articles purchased by farmers flour and lard show maximum, or nearly maximum, increase in prices in response to the higher prices obtained for wheat and hogs. To this rise in the price of articles of food there is one general exception, namely, the price of tropical or semi-tropical products, most of which show a decrease for reasons which do not exist in the case of products of the temperate zone.

The rise in the prices of agricultural products in the temperate zones is well illustrated in the case of raw materials used in the manufacture of clothing. Until this present year the price of cotton had shown a steady increase. The price of middling cotton per pound in the year 1895 was 7.44 cents in the New York market; in 1903 it was 11.18 cents; in 1910, 15.11 cents, or twice as much as fifteen years before. The price of fine wool in the month of January, 1895—for most of which year there was no duty—was in the eastern markets 17½ cents; in 1903, 30 cents, and in 1910, 36 cents. It may be added that cotton and woolen cloth in their various forms show a much less increase in

price than the raw products from which they are made.

The same general facts are true with relation to cereals and all other food products of the temperate zones. A cause additional to the lesser degree of assistance from invention may be found in the greater scarcity of land suitable for profitable cultivation and in our own country especially the early cultivation of fertile areas was conducted with too much regard for immediate returns and consequently little attention was paid to permanent productive quality. It is of course plain that farm products as well as all articles show an increased price by reason of the greater cost of wages and of most of the supplies which farmers must use. This, however, is common to all branches of production.

The unequal development in different lines of production has of late become especially noticeable in the case of precious metals. Formerly success or failure in gold or silver mining was largely a matter of chance. Now, however, as a result of the discoveries and improvements in engineering, and much more in chemistry, gold or silver mining has assumed the position of a settled industry in which calculations of the profitableness of treating certain ores or digging along a lode may be made with a fair degree of certainty. It may be added that improvements in production are unequal not only as regards different classes of useful articles, but also for different articles of substantially the same class. This is true of various lines of manufacture, hardly any two of which have been affected in the same degree. The manifest effect of this inequality in the ease or difficulty of production is a change in their relative value.

3. There is an inevitable tendency toward overaction, misdirected energy, waste and extravagance in every progressive era. This tendency has its roots in the very characteristics of human nature itself. It is due in part to the measure of uncertainty which pertains to all business undertakings and in part to the ambitions and dispositions of men. Whenever a new process is invented for satisfying a human want or a new market is discovered, it is probable that the inviting prospect of gain will cause an undue amount of investment and effort in that new direction, which results in a loss of capital and an over-supply of certain articles. The tendency to waste and extravagance is even more marked in the utilization of new facilities or the purchase of articles which please the taste or fancy. It is a well-known fact that the desire for the automobile has caused many persons to invest in this new luxury who could not afford it. A new style of house, or equipage, or of dress, all of which are common in a time of increasing wealth often lead to the discarding of that which under less favorable circumstances would be regarded as sufficient and to the purchase of other articles in accordance with present-day tastes or fashions. Social ambitions and the desire for luxury tend in the same direction; extravagance grows as facilities and attractive articles multiply. Along with these factors is the desire for ease and luxury which accompanies the accumulation of wealth. This is but a result of the fact that pleasure is more attractive than pain; that enjoyment is preferred to effort, hence the number of the unemployed increases and the amount of effort made for satisfying human wants diminishes.

An important factor of the present situation affecting the high cost of living is the rapidly growing cost of government, national, state and municipal. In case the proceeds derived from taxation are applied to essential improvements naturally no

waste would accrue, but there are nevertheless substantial differences between public and private enterprise. The former is managed with a less degree of care and supervision. Given a certain object, the expense of securing it by public management is usually greater than under private control. There is a still more important factor. The aim and nature of public expenditures differ materially from private investments. The latter are made with a view to an adequate return, a profitable income on the amount expended; in many instances, the former look to objects of a less essential nature, sometimes to monuments of grandeur or of art, which do not subserve any immediate purpose of utility. Public activities are often undertaken for conserving health or maintaining more perfect order and have in view considerations of general welfare most commendable in their nature, but such as would not be initiated in expectation of immediate profit. Again, they oftentimes provide for new facilities on a scale which private enterprise would not attempt. To all these must be added—and especial attention is called to this—the enormous burden of military and naval armaments now amounting, in the more civilized nations, to two billions per year, an economic waste which imposes an almost unendurable burden upon the world's resources. Again in prosperous times a disposition to indulge in excess and unwise undertakings is constantly manifest both in public and private expenditures. So long as there are limitations upon our ability to forecast the future, this will be true. No more helpful consummation in commerce and industry could be wished than that which by careful weighing of future needs and probabilities could adjust present activity to future demand.

In this connection it must be stated that the inequality of the supplies of raw material requisite for human needs is a prominent factor in the situation. The lumber supply of the United States, which at one time seemed abundant and even inexhaustible, in view of the great demand for buildings, furniture, implements, etc., has been diminished to such an extent as to threaten an early exhaustion. Perhaps the wisest policy would have suggested that the state limit the cutting of timber and require that new forests be planted. However that may be, the diminishing supply of timber in the face of unusual demand has caused a rapid increase in the price of products of the forest, the advance from 1900 to 1910 being the greatest of any single class. A comparison of the figures prepared by the Bureau of Commerce and Labor shows that between 1900 and 1910 the wholesale prices of wooden ware and furniture increased about 20 per cent., while the prices of window glass and grades of earthenware decreased nearly as much. For this divergence there is an evident explanation, namely, that the supply of timber is becoming more scanty while that of sand and clay and other materials for glass and earthenware is inexhaustible and readily available.

There have been numerous illustrations of the increase in prices in the history of progressive countries. According to Boeckh, in the time of Solon an ox in Athens cost 5 drachmas, or nearly 3 shillings, a sheep 1 drachma, a bushel and 3 gallons of corn 1 drachma. Two hundred years later the prices rose to five times and in many cases to ten or twenty times their former amount. The quantity of money was increased by the spoil obtained by successful military operations and by the development of mining in the islands of the Mediterranean, in Attica itself, and in Thrace and the island of Thesos. In

Rome it is more difficult to trace the changes in prices of food. Corn was sometimes exacted as a tribute from conquered countries and sold by the state at less than cost and occasionally given away. The increase of prices was particularly rapid after the concentration of the chief mining industry in the hands of the Roman government. Cattle increased in price as well as corn. About 400 B.C. sheep sold for 7 pence, 3 farthings. At the date of the Christian era the price was 25 shillings. After the Carthaginian wars the Romans acquired the valuable mines of their enemies in the western part of Africa, also in Sicily, Sardinia and the south of Spain. A few years later the mines of Greece and Asia Minor came into the possession of the Romans; still later the mines of Macedonia and Thrace. In their later conquest, special effort was made to acquire supplies of precious metal.

In the year 1581 a dialogue was printed, attributed to one "W. S.," probably William Smith, entitled "A Discourse of the Common Weal of this Realm of England." The participants in the dialogue are a knight or owner of land, supposed to be Mr. Thomas Hales, a doctor of divinity, who, as it is conjectured, was Bishop Hugh Latimer, a husbandman, a tenant farmer, a merchant, a mercer and a capper. An enterprising publisher in the year 1751 republished this dialogue and basing the authorship on the initials "W. S." assigned it to William Shakespeare, a manifest effort to obtain a greater sale by deceit. The real date of the dialogue as appears from more recent investigation was the year 1549. This document is exceedingly valuable for students who are considering the subject of high prices, for if we leave out the influence of the larger aggregations of capital, and the characteristic features of modern business, practically every reason for a rise in prices is advanced in it. Each ascribed to the occupation of the other the responsibility for the existing situation. Views are expressed upon the benefits of protective tariffs against foreign products, upon the balance of trade, upon the exactions of the middleman, upon the increase in rents of agricultural land. One of the characters expresses the opinion that avarice is the cause of high prices. Another mentions the great increase in the cost of necessary articles. One of them says: "Within these 8 years you could buy the best pig or goose that I could lay my hands upon for 4 pence which now costs me 8 pence and a good capon for 3 pence or 4, a chicken for a penny, a hen for two which will now cost me double the money, and it is likewise of great ware as of mutton and of beef." It was maintained in this discussion that price determined rent and not rent price. The husbandman conceded that if he were commanded to sell his wheat and other products at the old price he would have enough to pay his landlord as in times past, but he says that he must buy iron, salt, tar and pitch, all of which brought a higher price than formerly. One cause of the increase of prices, which is pointed out in this dialogue, is the clipping of coin which caused the good coins to go abroad for use in foreign trade. There were, however, more universal causes than this. Bodin, a French political philosopher, of the last half of the sixteenth century, states as an undoubted fact that there had been a revolution in prices. He gives six reasons for it:

1. The great abundance of gold and silver which resulted in a decrease in its purchasing power. The discovery of America and the increase of commerce and the development of banks caused the great abundance.

2. The monopolies of the Guilds and of the tax farmers.

3. The ease with which wine and corn—the chief products of France at that time—might be exported, thus increasing the price at home.

4. The extravagance of the Court.

5. The general leisure in the community.

6. The debasement of money, a practise which was prevalent in France at that time.

Mr. Jacob, in his excellent work on "Precious Metals," ascribes the increase in prices, of which complaint was made in the dialogue referred to, to the increased production of the precious metals and traces with great research the coincidence between their increased supply and the high prices of that time. A similar object lesson in the history of prices is derived from a comparatively recent period. In the years from 1789 to 1809, the average price of commodities rose from an index figure of 85 to 157, or more than 80 per cent. There were many contributing causes, such as the prevalence of war and the interference with international trade caused by the French Revolution and the Napoleonic wars. Mr. Tooke lays stress upon the poor harvests of that period, but Professor Jevons ascribes the increase to the larger production of gold and of silver and points out that metals and oils were more affected than grain. Beginning in 1809, for a period of 40 years, prices fell from an index number, as measured by Professor Jevons, of 157 to 64 or nearly 60 per cent. This decrease has been very generally ascribed to the falling off in the production of precious metals which did not revive until the gold discoveries in California and Australia. There was a temporary rise after 1839, apparently due to the inflow of Russian gold following its discovery in Siberia in 1830. The great activity prior to 1837 was also a contributing cause. It should be carefully borne in mind that this period from 1809 to 1849 was a time of great industrial advancement in which many inventions and improvements were utilized. In the period from 1849 to 1873, prices rose from 64 to 86, or about 33 per cent. The rise was interrupted by the crises of 1857 and 1866 and greatly accelerated by the exceptional activity prior to 1873 and was presumably due to the gold inflation following the development in 1849 in California and several years later in Australia. In the period from 1873 to 1896 prices fell in gold countries and this is ascribed to the decrease in the production of gold, to the adoption of the gold standard in the more advanced nations, thereby discontinuing the general use of one of the precious metals, at least as far as free coinage was concerned.

Manifestly there were other causes for the decrease in prices at this time. The great increase in facilities for transportation, culminating with the opening of the Suez Canal in 1869, brought different portions of the earth nearer to each other and made it possible to utilize the abundance afforded by outlying districts for the benefit of the more settled areas where food products were becoming less abundant. Again there were most notable increases in the mechanical arts. So considerable was this decrease in prices that several writers, of whom perhaps Mr. David A. Wells is the best example, came to the conclusion that the period of the most buoyant activity had come to an end; that thereafter the people would occupy themselves with repair and replacement or in utilizing discoveries already made. In other words, the most profitable production had reached a limit.

A very valuable contribution to the subject of prices is furnished by a comparison

between gold and silver standard countries. In India, where silver was still the money of the people, the index of prices rose from 107 in 1873 to 140 in 1896. In Japan it rose from 104 in 1873 to 133 in 1896, or a little less than 20 per cent., while in gold-using countries prices fell off more than 20 per cent. From 1896 to 1909 there has been a rise in prices contemporaneously with a great increase in the quantity of gold mined in South Africa and in different portions of the United States and Alaska.

Let us draw a little more fully the comparison between these eras of high and low prices and the production of gold. From 1789 to 1810, it has been stated that there was a rise in prices. During these years the average production of gold in the whole world was a little less than $12,000,000 per year, and that of silver approximately $37,000,000, or $49,000,000 in all. Beginning in the year 1811 the annual average for the next ten years was $7,606,000 of gold or a diminished supply of more than 33 per cent., and $22,000,000 of silver, a diminished supply of about 40 per cent. In the following decade from 1821 to 1830 there was an increase in the mining of gold and a decrease in that of silver, but the total annual average was slightly less than from 1811 to 1820. From 1831 to 1840 there was a substantial increase in both metals amounting to about 33 per cent. From 1841 to 1850 gold production increased from about $13,000,000 per year to $36,000,000. However, in the forty years from 1811 to 1850, inclusive, an era of low prices, the average annual production of gold was barely $17,000,000 per year; then with the opening of the mines in California and Australia the average suddenly rose from $17,000,000 to over $130,000,000, and to a still greater figure from 1856 to 1860. This was a period of rapidly rising prices. After this there was somewhat of a decrease. The lowest annual production was for the four years, 1874, 1875, 1876 and 1883, in each of which the production was between ninety and a hundred millions. A practically uniform and very large increase commenced in the year 1891 with $130,000,000, which increased to the enormous figure of $236,000,000 in 1897, after which with slight interruptions resulting from the Boer war, the still higher figure of $454,000,000 was reached in 1909. It thus appears that the production for the single year 1909 was more than two thirds as much as for the forty years from 1811 to 1850. It was greater than the combined coinage value of gold and silver for any year prior to 1898 and five times as great as the production of gold in the year 1874.

A further fact to be taken into account, of course, is the relation of the annual increment to the accumulated supply. Divers estimates of the world's stock of gold have been made. That which should be considered is the portion used for money in the form of coin or bars of bullion. At the present time the annual production is equal to at least three and perhaps four per cent. of the total existing monetary supply. Of the $454,000,000 mined in 1909, it has been estimated that $145,000,000 was utilized in the arts. It is probable that this is a large estimate, but in any event the primary money of the gold standard countries was increased by $300,000,000 in the year 1909. Indeed, according to the very carefully prepared estimate of Dr. Roberts, the Director of the Mint, the amount of coinage for that year is given as $313,000,000.

It is not by the mere addition of gold to the monetary supply that prices are raised. There is an even more important stimulus to activity in the fact that this money is

used as a basis of credit; that countries which heretofore have been without railroads and modern facilities are enabled to borrow for the construction of great railway lines and public works, the full benefit of which is often for a long time postponed. There is a marked increase in the demand for materials for this work. Labor is more constantly employed and at higher wages. The consuming power of the average human being is greatly increased. Speculation is rife and this tends to raise prices.

The connection between the increased supply of the precious metals and the general level of prices has been so marked and has appeared in so great a variety of countries and of periods as to preclude the possibility of mere coincidence. Of course certain modifying factors should be taken into account. The rise in prices after the beginning of the increase in the supply of gold or silver does not become manifest until some time has elapsed. This can be readily explained, because a substantial increase is necessary to modify the relation between the existing stock of the precious metals and the accretions.

Again, there has usually existed a concurrence of factors which make for increased activity and rising standards of living, on the one hand, and the increased supply of the precious metals, on the other. The development of gold mining on a large scale has followed closely after discoveries and inventions. This concurrence is such that while it would hardly be safe to generalize upon it, there is a strong presumption of a connection between the two. A somewhat similar cause of the rise of prices, by reason of the increased supply of gold among the militant countries of the ancient world, may be traced in their activities to secure the control of mines from which the precious metals were obtained.

The foregoing facts emphasize the importance of the so-called quantitative theory of money in considering the question of prices. To give adequate treatment to this theory and to estimate the effect of the volume of money upon prices would prolong this paper to an undue length. It would manifestly be incorrect to state the relation of the volume of money in circulation to the general level of prices as a simple equation. The problem is much more difficult. On this subject Mr. John Stuart Mill wrote in his work on Political Economy:

> The proposition respecting the dependence of general prices upon the quantity of money in circulation must be understood as applying only to a state of things in which money—that is, gold or silver—is the exclusive instrument of exchange, and actually passes from hand to hand at every purchase, credit in any of its shapes being unknown. When credit comes into play as a means of purchasing, distinct from money in hand, the connection between prices and the amount of the circulating medium is much less direct and intimate and such connection as does exist no longer admits of so simple a mode of expression.

Certain modifications are necessary in order to harmonize the quantitative theory with modern conditions. Only the amount of money actually in circulation can have any effect upon prices. That hoarded or out of circulation for other reasons can not exert any influence. On the one side, account must be taken of the variations in volume of transactions during periods of prosperity or depression and even at different seasons of the year. This factor affects the demand for the medium of exchange. On the other side, allowance must be made for the rapidity of circulation and the use of credit instruments which reinforce the monetary supply and thereby modify its influence upon the price level.

There are sundry current explanations of the present high prices which may be readily dismissed as untenable if advanced

as a reason for the general rise in the price level, however applicable they may be to the increase in the price of specific articles. What shall be said of the influence of the so-called trusts on prices? It is clear that complete monopoly or preponderant control of the market in the production or sale of any particular commodity affords opportunity to increase its price. The same result is apparent when separate producers maintain an agreement or understanding as to prices.

On the other hand, the superior economy and efficiency of large scale operations materially diminishes the cost of production and even more of distribution and should therefore tend to decrease prices. For this reason the concentration of industrial and commercial enterprise is a legitimate phase of business evolution. It must be said, however, with equal emphasis that thus far the general public has not experienced in reduced prices the benefit to which it is entitled because of the increased economy and efficiency resulting from great combinations. If the people do not receive their proper share of the benefits, strict control beginning with greater publicity and ending perhaps with the regulation of prices is the inevitable outcome. Certain it is that large scale operations have come to stay. If they can not be successfully regulated, it is probable that state ownership will be adopted in preference to a return to the old régime of smaller competing units.

In a majority of cases the statistics of prices do not bear out the assertion that the establishment of large corporations has always caused an exceptional increase in the cost to the consumer. In many instances, the higher prices are due in part at least to the greater expense of obtaining raw materials or to the increased labor and obsolescence charges to which all concerns of whatever magnitude are alike subjected. In the table prepared by the statistician of the Department of Agriculture, to which reference has been made, it appears that among over eighty enumerated articles purchased by the farmer, there were only three, the cost of which diminished between the years 1899 and 1909. Two of these are comparatively unimportant, the third is coal oil, which fell off from 15.1 cents per gallon in 1899 to 14.2 cents in 1909. There were also substantial reductions in the prices of various forms of iron and steel in the same period, while, as already mentioned, those of practically all the agricultural products of the temperate zone increased.

The rise in the price level can not be ascribed to tariffs any more than to the trusts, though prices of particular articles may have been increased by them. In answer to those who maintain that the tariff is responsible for the high cost of living in the United States, attention may be called to the admitted fact that the rise in the price level has been universal under free trade, as well as under revenue and protective tariffs. In a single newspaper published at Paris last September, there were paragraphs giving accounts of meetings, some of which were attended by violence, in Berlin, Switzerland, Bohemia, Silesia and Galicia to protest against high prices. In other issues at about the same time there were paragraphs giving accounts of bread riots in France and of loud complaints against the high cost of living in England and Belgium.

It is a noticeable fact that many prices have risen in spite of reduced tariffs in our own country, as in the case of hides and shoes. In the whole list of increases in prices from 1899 to March, 1910, there is no more notable illustration than that of crude rubber, on which there is no duty.

The price rose from 80 cents in the former year to $1.99½ in 1910. On the other hand, raisins and prunes, upon which there is a considerable duty, have shown a material fall, and sugar has not greatly increased in price except very recently, due it is claimed, to crop conditions. Instances might be indefinitely multiplied of the rise and fall of prices here and elsewhere irrespective of the duties levied. These illustrations show that the tariff is only one of the numerous causes affecting relative prices. It may often happen, as in the cases cited, that other causes so far outweigh the influence of the tariff that its effect can not be discerned.

As regards the cost of labor, while a high standard of wages is maintained in the United States and there have been notable increases in the wages of many classes of employees, it can not be said that there has been a disproportionate increase; the facts are quite the contrary because, generally speaking, the cost of living has more than kept pace with the increase in compensation.

As a rule, wages as well as retail prices do not immediately respond to changes as readily as wholesale prices or as rent and other items which make up the ordinary expenses of living. The basic fact which should be considered is the relative proportions of personal service and of improvements accomplished by inventions or labor-saving devices, in the production or distribution of any commodity. In cases in which machinery renders a more efficient service than formerly, the tendency is toward downward prices, but in case labor or personal service has been only partially aided by these improvements, or as in some cases not at all, the prices have increased.

Under modern systems of distribution the amount of personal service required is relatively much greater than formerly and in this fact may be found a very important cause of high prices. Much more care is exercised in the preparation and handling of packages. Delivery is made to the consumer at his residence. There is no sufficient organization in distribution. As a result there is a vast amount of duplication. This service involves an exceptional cost as compared with the work of distributing large quantities. For example, the carrying of a ton of coal 150 miles to a city costs less than the transfer of that coal for a half or even a quarter of a mile to the home in which it is consumed. The cost of delivery of mail matter by carriers in cities and on rural free delivery routes is much in excess of the carriage in bulk by railway or steamship, even for very long distances.

Innumerable examples may be given of the very considerable difference between the original cost to the manufacturer and the final charge to the consumer. Some weeks since figures were carefully prepared in regard to the manufacture and sale of an article of clothing now in very general use. The manufacturer charged $24.90 per dozen. Each dozen included different sizes. The retailer charged from $4 to $10 per garment. The total sales averaged about $6.50 for each, or a total of $78 to the consumer as against $24.90 to the manufacturer. The retailer is not to be blamed. The pressure of population in cities, the greater demands of modern life resulting in higher rents and higher cost for services rendered to him, make it essential that he should charge more for the goods he sells.

An entire revolution in methods of distribution is imminent. The consumer will be brought nearer to the producer. Great warehouses will be substituted for small and scattered shops, especially in case of

staple articles where confidence in the seller or exceptional skill are not essential features. The possible economy of large-scale production and the undertaking by one organization of the various processes, even from the raw material through manufacture and distribution to the consumer, has been demonstrated by some of the great corporations of the country. However much we may decry this tendency, we may be reasonably certain that it will be adopted more and more in the future.

It would be rash to predict an early return to low prices. All the great factors which I have partially portrayed depend upon new conditions which have arisen, some of which are inseparably connected with substantial benefits to the human race. If prices have increased, human enjoyment has increased also.

That which is most noticeable in the consideration of this problem is the wide variation in the changing cost of divers commodities and facilities. After making due allowance, however, for this variation, there is a manifest increase in the general price level. Great economic laws will be potent in their effect upon these conditions. The enormous increase in the production of gold will be checked as this metal becomes less valuable in comparison with useful articles. Indeed, this fact is already forecast by the diminished annual increase in the years 1910 and 1911. The increasing price of farm products may stimulate a "back to the farm" movement, but whether this proves true or not it will undoubtedly encourage more scientific methods of cultivation and thus increase the average yield per acre. More intelligent and more adequate control will be exercised over great industrial and commercial organizations so that the benefit of modern developments in industry and commerce may accrue in proper measure to all classes of consumers.

The same advances which have been made in production and in the distribution of great masses of commodities will, as far as possible, be applied to the minutest details of distribution. Our natural resources which have been wasted, or too largely absorbed by the few, will be more carefully utilized and every possible means be taken to preserve a proper share of them for the future. Thus in this present increase of prices as in all great economic changes there may be reasonable assurance that the ultimate effect will bring to all substantial benefit rather than harm.

T. E. Burton

THE CENTENARY OF THE ACADEMY OF NATURAL SCIENCES OF PHILADELPHIA

Early in the past year resolutions were adopted by the council of the Academy of Natural Sciences of Philadelphia approving of a fitting celebration of the centenary of the society on the nineteenth, twentieth and twenty-first of next March. The president appointed a committee of forty-one to make arrangements for such celebration.

The general committee, of which the president, Samuel G. Dixon, M.D., LL.D., is chairman, has been divided into sub-committees on printing and publications, meetings and addresses, invitations, finance and entertainment. In harmony with a preliminary report of this committee the publication of three volumes has been decided upon: A commemorative quarto volume of scientific memoirs, adequately illustrated; an index to the series of *Proceedings* and *Journal* up to and including 1910, now amounting to nearly one hundred volumes, and a detailed history of the academy by Dr. Nolan, of which the chapter contributed by him in 1908 to the "Founders' Week Memorial Volume" may be considered a prodromus. The last mentioned volume will be illustrated by portraits and views.

It has been decided to hold the first session on the meeting night of the academy, on

March 19, when delegates will be received and historical addresses will probably be delivered; two morning sessions will be devoted to the reading of scientific papers by members, correspondents and delegates; on the afternoon of the second day a microscopical exhibition will be given and the resources of the academy demonstrated; on the evening of that day a reception will be tendered by the president to members, guests and friends; and the proceedings will end with a banquet on the evening of March 21, the official birthday, of the academy.

The preparation of the proposed publications is progressing satisfactorily and the dignity and importance of the commemorative volume is assured. It is hoped that a united effort may be made to secure for the occasion a success commensurate with its importance in the history of the academy and in its relation to the advancement of science in America.

SCIENTIFIC NOTES AND NEWS

DR. FREDERIC A. LUCAS, director of the American Museum of Natural History, has been made a corresponding member of the Zoological Society of London.

DR. AUGUST WEISMANN, professor of zoology in the University of Freiburg, will retire in April.

DR. GEORGE B. SHATTUCK has retired from the active editorial management of the *Boston Medical and Surgical Journal* after a service of thirty-one years.

WE learn from the *Journal* of the American Medical Association that Professor Theodor Ziehen, director of the psychiatric and neurologic clinic in Berlin, will resign his position at the end of the winter semester and discontinue all medical work, in order to devote himself exclusively to research in psychology. For this purpose, he will remove to Wiesbaden, where he will erect for himself a private psychological laboratory.

PROFESSOR ARMIN BALTZER, Berne, and Dr. Emmanuel de Margerie, Paris, have been elected foreign members and Professor Charles Depéret, Lyons, and Professor Arvid Gustaf Högbom, Upsala, have been elected foreign correspondents of the Geological Society of London.

M. LECLAINCHE, professor in the veterinary school at Toulouse, has been elected a corresponding member of the Paris Academy of Sciences, in the section of agriculture.

AT the ordinary scientific meeting of the London Chemical Society on December 21, 1911, it was announced that the council had awarded the Longstaff medal for 1912 to Dr. H. Brereton Baker, F.R.S.

AT the dinner of the Western Society of Engineers, Chicago, on January 10, announcement was made of the award of the Octave Chanute Medal for 1910 in electrical engineering to Mr. H. B. Gear, general inspector of the Commonwealth Edison Company, Chicago, for his work on "devices for the distribution of electric light and power." Mr. C. P. Berg received the medal for mechanical engineering in the heat treatment of high-speed tools, and Mr. C. K. Mohler was awarded the medal in civil engineering for his studies of earth pressures.

THE Institution of Mining and Metallurgy of Great Britain has awarded gold medals as follows: Gold Medal of the Institution (two awards): (*a*) to Mr. E. P. Mathewson, M.Inst.M.M., general manager of the Anaconda Copper Company, Arizona, in recognition of his services in the advancement of metallurgy generally, and especially in regard to copper; (*b*) to Mr. Walter McDermott, M.Inst.M.M., in recognition of his services in the equipment of the Bessemer Laboratory of the Royal School of Mines and as the representative of the institution on the Board of Governors of the Imperial College of Science and Technology during the period of its establishment and organization; and to signalize his services in the advancement of metallurgical practise. The Consolidated Gold Fields of South Africa (Limited) Gold Medal to Mr. Walford R. Dowling, M.Inst.M.M., for his paper on "The Amalgamation of Gold in Banket Ore."

PROFESSOR H. W. RILEY, head of the de-

partment of farm mechanics of the College of Agriculture of Cornell University, was elected president of the American Association of Agricultural Engineers at the annual convention recently held at St. Paul, Minn.

At the meeting of the American Society of Bio-chemists, held in Baltimore, the following officers were elected: *president,* Dr. Archibald B. Macallum, University of Toronto; *secretary,* Dr. A. N. Richards, University of Pennsylvania; *treasurer,* Dr. Walter Jones, Johns Hopkins University; *councilors,* Drs. L. B. Mendel, Yale, and H. Gideon Wells, University of Chicago.

Dr. Edward G. Dexter, of Illinois, has been renominated by President Taft to be commissioner of education for Porto Rico.

Mr. J. C. Th. Uphof, of Amsterdam, author of "Die Pflanzengattungen," has been appointed gardener for the Botanical Garden at the Michigan Agricultural College. He will also do work in connection with the herbarium. He is expected to enter upon his duties in the latter part of February.

Professor Theodore Pfeiffer, of Breslau, has declined a call to the directorship of the Agricultural Experiment Station, Möckern, near Leipzig.

Mr. N. C. Nelson, instructor in anthropology in the University of California, has been appointed assistant curator in the department of anthropology, American Museum of Natural History. He will assume his duties next June and will give especial attention to North American archeology. Mr. George Borup, who was in charge of the third supporting party of Admiral Peary in his last polar expedition, has been appointed assistant curator in the department of geology and invertebrate paleontology.

Dr. Weber has been appointed director of the imperial health office, Berlin, to succeed Professor Uhlenhuth, who is at present director of the hygienic institute at Strasburg.

Dr. Erwin Erhardt, of the University of Munich, is visiting the United States to study methods of treating cancer.

Dr. L. A. Bauer has returned to Washington after a nine months' trip of inspection of the magnetic work being conducted, under the auspices of the Carnegie Institution of Washington, on board the *Carnegie* in the Indian and Pacific oceans and by land expeditions in Australia and Asia. *En route* he also visited the various magnetic institutions in the Pacific Islands, New Zealand, Australia, India, Burma, Java, China and Japan, and observed the total solar eclipse of April 28 at Tau Island of the Manua group.

The Auk states that Mr. Roy C. Andrews, assistant curator of mammalogy in the American Museum of Natural History, sailed for Korea on December 13. He expects to spend about two months at the whaling stations there, for the purpose of studying and securing specimens of the California gray whale and humpbacked whale. He then plans a trip into the mountains of northern Korea, known as Chokaku San, where about four months will be spent in collecting mammals and birds, if possible in regions not hitherto visited by zoologists.

Mr. Walter Granger, associate curator of fossil mammals in the American Museum of Natural History, is abroad engaged in part upon researches among the fossil mammals of the English and French museums, especially the old world relatives of the four-toed horse.

At the third lecture in a series on biological topics being given before Trinity College Frederic S. Lee, Dalton professor of physiology, College of Physicians and Surgeons, New York, exhibited, for the first time in this country, cinematograph films representing phases of muscular action, such as the reaction of the perfused heart to various agents, ciliary and flagellate motions in *Trypanosoma,* etc.

Captain H. G. Lyons, F.R.S., late director of the Egyptian Survey, will give a course of lectures before the Royal Geographical Society on February 9, 13 and 16 on the North African Desert.

A portrait of the late Dr. John Ashhurst, Jr., has been presented to the College of Physicians, Philadelphia.

DR. JEAN BAPTISTE EDUARD BORNET, the algologist, member of the Paris Academy of Sciences, has died at the age of eighty-two years.

THE death is announced of William Thynne Lynn, former assistant at the Royal Observatory at Greenwich, at the age of seventy-six years.

DR. JAN. KOWALEZYK, astronomer in the observatory at Warsaw, has died at the age of seventy-eight years.

M. ARTHUR DE CLAPARÈDE, the geographer, has died at Geneva, at the age of fifty-nine years.

THE sixth triennial congress of the International Association for Testing Materials will be held in the Engineering Societies building, New York, beginning on September 3, 1912.

A JOINT meeting of the British Institution of Mining and Metallurgy and the Canadian Mining Institute will be held at Toronto on March 6, and the following days.

THE *Bulletin* of the American Mathematical society states that a new journal, entitled the *Vector* has been established at Warsaw. It will be devoted to mathematical and physical science in general and especially to questions of method and pedagogy.

Nature states that the council of the London School of Tropical Medicine has decided to establish a journal in connection with the school. Three parts are to appear each year, and part I. has just been issued. Sir Patrick Manson writes a foreword; original papers are contributed by Drs. Bayon, Daniels, Hutton, Leiper, Minett and Wise; and surveys of recent literature on tropical medicine and reviews of books complete the matter.

UNIVERSITY AND EDUCATIONAL NEWS

THE will of the late Mrs. Emily Howe Hitchcock provides that the Hitchcock mansion and the estate of forty-five acres, valued at $50,000, shall go to Dartmouth College. To the college is also left Mr. Hitchcock's Di Cesuela collection of Cyprus antiquities. To the Mary Hitchcock Memorial Hospital, connected with Dartmouth, is left an endowment fund of $20,000, and to the Howe Library of Hanover, occupying the ancestral home of Mrs. Hitchcock, an endowment of $50,000. To the Pine Park Association, a society formed to preserve the natural beauties of the town, is bequeathed a large tract of woodland adjoining the Vale of Tempe.

THE Marquise Arconati Visconti has given 500,000 francs to the faculties of science and arts of the University of Paris.

DURING commencement week, June 23 to 27, inclusive, the University of Michigan will celebrate the seventy-fifth anniversary of its founding.

CIRCULARS of information concerning the Kahn foundation for the foreign travel of American teachers have been issued by the trustees of the foundation. Two fellows will be appointed for one year beginning July 1, 1912, with a stipend of $3,000 and an additional $300 for the purchase of books, souvenirs, photographs, etc. The applications for appointment should be made on a formal blank which may be obtained from the secretary of the foundation, Sub-station 84, New York City, and should be filed on or before March 1, 1912. The present holders of the fellowships are Professor J. H. T. McPherson, of the University of Georgia, and Professor Francis Daniels, of Wabash College. They both sailed from this country during the summer and will have completed their year's travel by about August 1, 1912. They are both planning to make a complete trip around the world.

THE course on "Water Analysis and Water Supply" at the Rensselaer Polytechnic Institute has been expanded so as to allow of a preliminary course being given on "plankton" where special attention is devoted to those growths which produce taste and smell in reservoir water. Upon the completion of the above water course, each student is required to spend two weeks at work on local municipal slow sand filter beds and also on filters of mechanical type whereby he acquires a practical knowledge of the workings of full-

sized city filter plants. The cities in the neighborhood of Troy supply good illustrations of the different modern methods of water purification.

The *Bulletin* of the American Mathematical Society states that during the Easter vacation of 1912 an extensive course in mathematics and physics for advanced teachers will be held at Göttingen under the direction of Professor F. Klein.

Dr. C. Rankiär has been appointed professor of botany, and director of the Botanical Gardens at Copenhagen.

Dr. Gilbert T. Morgan, assistant professor of chemistry at the Imperial College of Science and Technology, South Kensington, and junior hon. secretary of the Chemical Society, has been appointed to the chair of chemistry at the Royal College of Science, Dublin, vacant by the retirement of Sir Walter Noel Hartley, F.R.S.

Dr. Theodor Boveri, professor of zoology at Würzburg, has been called to Freiburg.

DISCUSSION AND CORRESPONDENCE

NUMBER OF STUDENTS PER TEACHER

To the Editor of Science: It appears to me that the only correct way to determine the average number of students handled per teacher in any school is to divide the number of student hours per week by the number of teacher hours per week.

For example, let there be 15 teachers and 300 students. This does not mean that on the average one teacher instructs 20 students in a recitation or class. Suppose each student takes 15 hours per week, and that each teacher instructs only 12 hours per week. There are therefore 15×12 classes per week for 300×15 students, since each student appears in 15 classes. The average number of students in each class is therefore

$$300 \times 15 \div 15 \times 12 = 25.$$

In general, therefore, the average number of students which each instructor has to handle in one recitation is the number of student hours divided by the number of teacher hours, in one week.

The average number of hours per week required of each student and each teacher, viz., the number of student-hours and teacher-hours per week divided respectively by the number of students and teachers, are also important numbers in respect to the average work required of students and teachers.

Arthur S. Hathaway
Rose Polytechnic Institute

FUNDULUS AND FRESH WATER

"*Fundulus* and Fresh Water" in your issue of December 29, 1911, recalls some experiences I have had with these fishes in transferring them from salt and brackish to fresh water. *Fundulus heteroclitus* may be so transferred more safely, the less degree of salinity there is in the water whence they were derived. Most of my specimens came from the Hackensack River and its creeks, varying from the saline Newark Bay to the almost entirely fresh water at Little Ferry and at the heads of the creeks. While very few of those transferred from salt water directly to fresh survived the sudden change, an increasing number survived of those gradually transferred in the course of a week or two, through a number of changes of water. My records show that such fishes lived from four to six months, up to two years; one lived over three years. I never succeeded, however, in making a successful transfer of the highly colored breeding males.

Fundulus diaphanus, though known almost entirely as a fresh water species, when taken from salt water also offers difficulties in transferring, thus showing that successful transfer in all cases appears to be a matter of very gradual accomplishment.

Fundulus majalis I never succeeded in transferring, no doubt because of its being a purely marine species.

Cyprinodon variegatus also can be gradually accustomed to a change of water, but being practically only an anadromous fish during breeding time does not very long survive.

It is possible that these cyprinodonts being great rovers can ill bear small quarters and this may be one reason for their shortlivedness in captivity, as compared with the quieter cyprinids for instance.

Transfers were never successfully made to "*hard*," that is, well water. I never used distilled water but simply rain or city tap water.

Experiments made with Sticklebacks.—*Gasterosteus aculeatus* and *pungitius* and *Apeltes quadracus* also bear transfer which may ordinarily be made quite suddenly and without great loss. I transferred back an *aculeatus* directly from fresh to salt water; it survived only a few days, but as it was a spent male (in the fresh water) this may not be considered a fair test.

Suddenly transferred fishes drop to the bottom of the tank and slowly move about after some time; this is due to the difference in density chiefly, but differences in the temperatures of the water also have this effect, though it is sooner overcome.

EUGENE SMITH

HOBOKEN, N. J.

SCIENTIFIC BOOKS

The Flora of Boulder, Colorado and Vicinity. By FRANCIS POTTER DANIELS. Volume II., No. 2, University of Missouri Studies. Price, $1.50.

The author of this excellent piece of work is not a professional botanist but a specialist in Romance languages. While engaged in teaching French in the summer session of the University of Colorado in 1906 he made the collections upon which the present report is based. Through the University of Missouri, with which institution Dr. Daniels was formerly connected, his book of over 300 large octavo pages has been issued as a number of the "University of Missouri Studies." It is sumptuously printed in large type with wide margins and generous spacing.

Dr. Daniels collected 1,036 species of plants during the single summer that he was in Boulder. To this number are added in his printed list some species reported from the vicinity in Rydberg's "Flora of Colorado" together with others from various sources. The total number listed seems to be about 1,240. At various points in the body of the list new species and varieties are described. It is unfortunate that because of lack of time Dr. Daniels was unable to consult the university herbarium at Boulder. This collection, containing some 5,000 sheets of Boulder County specimens, is, therefore, not reported upon in the present publication. However, the large number of plants collected by the author himself must surely comprise a very considerable part of the flora. His list is bound to be of great use to students of the local flora.

In addition to the systematic list of species and localities there is a fifty-page introduction in which various ecological matters are discussed. This is evidently not written for the professional botanist for the language is popular, not to say "breezy." One is therefore just a bit surprised by such terms as *Ensiformes, Rimosæ,* etc., which, set in heavy bold-face type, stare uncompromisingly at the patient reader who may happen to be innocent of a knowledge of the classical languages.

A very full index completes this creditable publication.

FRANCIS RAMALEY

UNIVERSITY OF COLORADO,
BOULDER, COLO.

SCIENTIFIC JOURNALS AND ARTICLES

Terrestrial Magnetism and Atmospheric Electricity for September, 1911, contains the following articles:

"Magnetic Chart Errors and Secular Changes in the Indian Ocean," by L. A. Bauer and W. J. Peters.

"Comparisons of Magnetic Observatory Standards by the Carnegie Institution of Washington, No. II.," by J. A. Fleming.

"Data for Abruptly-beginning Magnetic Disturbances, 1906–1909, No. II.": Reports from Batavia-Buitenzorg; Zi-ka-wei and Lu-kia-pang; Kew; Mauritius; Eskdalemuir; Dehra Dun, Kodaikanal, Barrackpore and Toungoo; Tortosa; Samoa; Falmouth; De Bilt; Rud Skov; Pilar; and additional data for Potsdam; Agincourt; Porto Rico, Cheltenham, Baldwin, Sitka and Honolulu.

"Peculiar Magnetic Disturbances of December 28–31, 1908," by R. L. Faris.

"The Magnetic Character of the Year 1910," by G. van Dijk.

"Mean Values of the Magnetic Elements at Observatories," compiled by J. A. Fleming.

Articles in the December issue are:

"On the Magnetic Field of the Earth," by L. Steiner.

"The Physical Theory of the Earth's Magnetic and Electric Phenomena, No. IV.," by L. A. Bauer.

"Atmospheric Electricity Observations on the Second Cruise of the *Carnegie* from New York to Colombo," by E. Kidson.

"On the Normal Magnetic Elements at the Mauritius Magnetic Observatory," by L. A. Bauer.

TREMATODE GENERIC NAMES PROPOSED FOR THE "OFFICIAL LIST OF ZOOLOGICAL NAMES"

1. The International Commission on Medical Zoology, appointed by the Graz International Zoological Congress, has made its first report on the names of Trematode genera parasitic in man.

2. Four members, namely, Blanchard (Paris), Monticelli (Naples), Stiles (Washington) and Zschokke (Basel), unanimously agree that the following eleven names are from the present standpoint of systematic zoology and nomenclature, the correct names for the genera in question, and that the species cited as genotypes are the correct types according to the International Rules of Zoological Nomenclature.

Clonorchis Looss, 1907, Feb. 1, 147–152, type *sinensis.*

Dicrocœlium Dujardin, 1845*a*, 391, type *lanceatum* = *lanceolatum* (= ? *dendriticum* sub judice).

Fasciola Linnæus, 1758*a*, 644, 648–649, type *hepatica.*

Fasciolopsis Looss, 1899*b*, 557, 561, type *buskii* (seu *buski* teste Blanchard).

Gastrodiscus Leuckart in Cobbold, 1877*e*, 233–239, type *sonsinoii* (seu *sonsinoi* teste Blanchard).

Heterophyes Cobbold, 1866*a*, 6, type *ægyptiaca* = *heterophyes.*

Metorchis Looss, 1899*b*, 564–566, type *albidus.*

Opisthorchis Blanchard, 1895*f*, 217, type *felineus.*

Paragonimus Braun, 1899*g*, 492, type *westermanii* (seu *westermanni* teste Blanchard).

Pseudamphistomum Luehe, 1908, 428–436, type *truncatum.*

Watsonius Stiles & Goldberger, 1910, 212, type *watsoni.*

3. The following commissioners have not voted: Jaegerskioeld (Gothenburg), Looss (Cairo), Luehe (Koenigsberg), Pintner (Vienna) and Shipley (Cambridge).

4. Notice is hereby given that the undersigned will wait until July 1, 1912, for any zoologist to raise objection to any portion of this report, and that on that date all names to which valid objection is not raised will be forwarded to the International Commission on Zoological Nomenclature with the motion that these names be included in the "Official List of Zoological Names" provided for by the Graz Zoological Congress.

5. All correspondence on this subject should be addressed to

C. W. Stiles,
Secretary International Commission on Zoological Nomenclature
Hygienic Laboratory,
Washington, D. C.,
November 11, 1911

SPECIAL ARTICLES

NOTES UPON CRONARTIUM RIBICOLA[1]

A number of new points have been worked out in connection with this fungus during the past year. A coarse yellow mottling of pine needles and of the bark on the twigs and leader occurs rarely, but is very characteristic when it does occur. It seems to occur only in trees which have had the disease for more than one year. It has developed in the greenhouse upon plants which were known to be infected and has been found in one lot of trees set out in the field.

In 1910 an attempt was made by the speaker to pick out all the infected trees in a lot of 10,000 three-year-old white pines. The remainder were then planted out by state authorities in a large open field where every tree could be easily found the next year, and in a locality where *Ribes* were absent for a considerable distance. An examination the next summer showed a considerable number which had swellings of the bark, but none were found with fruiting bodies of the *Perider-*

[1] Presented before the American Phytopathological Society, December, 1911.

mium. This, together with other experience along similar lines, convinced the speaker that the best single inspection possible will not remove all infected trees from a diseased lot. There will be at least a few hold-over cases which will develop afterward. This makes repeated inspection absolutely necessary and such repeated inspections *very* soon cost more than the value of the entire lot of trees. In most cases it will be real economy to pull up the trees and burn them at once.

The speaker, in cooperation with the state authorities, discovered the disease for the first time in the states of New Jersey and Virginia in 1911. In the former case the entire lot was destroyed by the owner, while the action taken in the latter is not known. No fruiting bodies were found in Virginia, but the swollen stems were present in a few cases. During the past year the disease has been shipped to us by a French firm and inquiry showed that they raised their trees themselves.

The finding of the teleuto stage of the fungus affecting the stipule and bracts of a *Ribes* leaf in the greenhouse, is believed to practically prove that the fungus may sometimes attack the bud scales of dormant bushes and cuttings; this very probably explains the anomalous appearance of this fungus in this country upon *Ribes* at Geneva, N. Y., and possibly in Kansas.

The single German nursery of J. Heins's Sons has sent us over 95 per cent. of the total amount of diseased stock that has been found in this country, yet they say they have no disease in their nursery. Barely a month ago the writer received samples of their white pine stock, which had just been submitted to the superintendent of the New York State Forests by Heins's Sons, and one at least had visible swelling of the stem, which the writer is confident is caused by the blister rust. This shows that he was correct in his former suspicion that they do not know the field characters of this disease. Inoculations have been successfully made by the writer with spores from diseased white pine trees sent by J. Heins's Sons to Lake Clear Junction and Salamanca, New York, and to the states of New Jersey and Connecticut, upon *Ribes* in the greenhouse. The shipments thus tested were made in 1908, 1909 and 1910.

Experience with greenhouse inoculations on *Ribes* shows that the teleuto stage develops only after the cool weather of autumn sets in: that is, the uredo stage flourishes through the summer, but the teleuto stage does not appear until cooler weather prevails. The experiments for two years agree in showing this peculiarity. Greenhouse inoculations have been made upon young *Pinus strobus* with teleutospores secured by inoculation on *Ribes americanum* with æcidiospores borne upon imported trees of *Pinus strobus*. Inoculations thus made in November, 1910, are now beginning to give results. One each of the trees inoculated with wounds and without wounds is now showing slight swelling such as is so characteristic of the blister rust disease.

PERLEY SPAULDING
OFFICE OF FOREST PATHOLOGY,
BUREAU OF PLANT INDUSTRY,
U. S. DEPARTMENT OF AGRICULTURE

THE BOTANICAL SOCIETY OF AMERICA

THE annual meeting of the Botanical Society of America was held at the Business High School, Washington, D. C., December 27 to 29, 1911.

The following were elected officers for the ensuing years:

President—L. R. Jones, University of Wisconsin.

Vice-president—B. M. Duggar, Cornell University.

Secretary—G. T. Moore, Washington University.

Councilor—Wm. Trelease, Missouri Botanical Garden.

These, with Arthur Hollick, treasurer, and C. L. Shear and R. A. Harper, councilors, constitute the council for 1912.

The following associate members were elected to full membership: D. H. Campbell, Stanford University; M. L. Fernald, Harvard University; J. B. Overton, University of Wisconsin; P. H. Rolfs, Florida Experiment Station; P. A. Rydberg, New York Botanical Garden.

Botanists elected to associate membership were: I. W. Bailey, Harvard University; F. S. Collins, Malden, Mass.; C. W. Edgerton, Louisiana Experiment Station; J. H. Faul, University of Toronto; R. McM. Harper, University of Alabama; H. Hasselbring, Bureau of Plant Industry; C. E.

Lewis, Maine Experiment Station; F. Ramaley, University of Colorado; D. Reddick, Cornell University; Frances G. Smith, Smith College; A. Stewart, University of Wisconsin; H. N. Whitford, Bureau of Forestry, Manila; F. D. Wolf, Alabama Experiment Station.

The address of retiring President Erwin F. Smith on "Some Aspects of the Relationship of the Crown-gall Disease to Human Cancer" and the symposium on "Modern Aspects of Paleobotany," participated in by F. H. Knowlton, John M. Coulter, Edward C. Jeffrey and Arthur Hollick, will be published and distributed to the members of the society.

The dinner for all botanists was held Thursday night. Mr. David Fairchild was toastmaster and a number of botanists spoke briefly upon the particular aspect of work in which they were interested.

The smoker given by the members of the Washington Botanical Society to all visiting botanists, on Friday night, was largely attended and a most enjoyable affair.

Following are abstracts of papers presented at the symposium on "Modern Aspects of Paleobotany":

I. *The Relations of Paleobotany to Geology:* F. H. Knowlton.

The present paper emphasizes the fact that paleobotany, in common with all the other branches of paleontology, admits of subdivision into two lines or fields of study—the biological and the geological—depending upon the prominence given to the one or the other of these phases of the subject. As the biological side is to be handled by other contributors to this discussion, the present contribution is, naturally, confined to the geological aspects of the science. It is shown that fossil plants afford a series of stratigraphic marks, serving for the identification of geological horizons, that are unsurpassed in value by those afforded by any of the many other branches of paleontology; and nowhere in the world is this fact so thoroughly recognized and accepted as in North America. Objection is frequently made, especially by botanists, that impressions of plants, the form in which they are most utilized by geologists, are often of doubtful biologic value. In reply to this it is shown that while the paleobotanist uses his utmost endeavor correctly to fix the biologic status of the material he uses, it makes not the slightest difference to the stratigraphic geologist whether the fossils upon which he most relies are correctly named, biologically, so long as their horizon is known and they are clearly defined and capable of recognition under any and all conditions. The various phases of this aspect of paleobotany are set forth in detail, especially in its general geological and economic applications. The value of paleobotany in the interpretation of geological climate is also treated at some length.

II. *The Relations of Paleobotany to Botany.*

1. *Phylogeny and Taxonomy:* John M. Coulter.

It is impossible to disentangle morphology and phylogeny, for the largest motive in modern morphology is to construct phylogenies. An excessive amount of overlapping will be avoided in this paper by laying the emphasis upon the inferences to be drawn from morphological investigations as to probable lines of descent, rather than upon the morphological results themselves.

As a result of the recently developed paleobotanical connections, the phylogeny of the vascular groups can be made now a resultant of comparative structures and actual history. Many an old phylogeny, based upon the comparative structures of existing plants alone, has been contradicted by history, which, in the nature of things, must furnish the final check upon any proposed phylogeny.

The title of this paper includes the taxonomy, but in so far as this deals with great groups, defined or discovered, it is covered by the statements concerning phylogeny. So far as it deals with the recognition of individual forms, it is clear that paleobotany must learn to recognize the relationships of fossil plants, or there will be no reliable taxonomy or phylogeny. So long as paleobotany depended upon the form resemblances of detached organs, there could be no taxonomy in the real sense. It was merely a cataloguing of plant material. But when it learned to uncover structure, it began to establish a real taxonomy. The contributions of paleobotany to taxonomy, therefore, may be summed up in the statement that it has begun to extend our schemes of classification into the ancient floras; that this has resulted in a far truer view of the great groups than their expression in the present flora can possibly give; and that this makes a rational phylogeny possible.

Illustrations are given of the great changes of view, brought about by paleobotany, that have occurred during the last decade. The illustrations are taken from the Lycopodiales (*Lycopodium, Selaginella, Isoetes*), showing the present opinion

as to the relation between the paleozoic and the present representatives; from Equisetales, showing the recent development of knowledge in reference to the paleozoic forms; from Filicales, showing the disappearance of the paleozoic assemblage once called ferns, and the development of knowledge in reference to Palæo-Marattiaceæ and Priniofilices; and especially from Gymnosperms, showing the remarkable reconstruction of the phylogeny of that group.

The great problem of paleobotany to-day is the history of angiosperms. Having perfected a weapon in the attack upon gymnosperms, it remains for the paleobotanist who is a vascular anatomist to uncover the origin of our greatest group, with its comparatively brief history. The origin is probably recorded in the Mesozoic, and we wish to see the significant structures, and not guess at external form, and much less guess at purely hypothetical connections. To this great task paleobotany is turning. We have had the guesses; and I am confident that presently we will have the facts.

2. *Morphology:* EDWARD C. JEFFREY.

The often perfect condition of preservation of plant fossils and the comparatively unbroken series, which they present, from the remotest times to the present, has been of the greatest importance for the modern development of plant morphology. It is now clearly recognized that the doctrine of recapitulation, far from being solely exemplified by zoologic types, is much more clearly and certainly deducible from the historical and developmental study of plants, which in this as in so many other respects, show themselves more advantageous for evolutionary studies than animals. It is clear likewise from the studies of the past decade, or decade and a half, that external morphology, even that of the reproductive organs, is of comparatively slight importance in connection with the doctrine of descent or its practical application to the natural system. Applied to the internal structures, the doctrine of recapitulation has many and striking illustrations in plants living and extinct. The correlation of paleobotany with internal morphology has shown, moreover, that the investigation of reversions is a very profitable direction of scientific exploitation. In addition to exemplifying recapitulation and reversion, plants further present another law, which is for the most part not apparent in animals. It has been shown, namely, that of the separate organs of the plant, the stem is most progressive and that root and leaf lag behind in evolutionary development. As a consequence it is often possible to discover the structures of a remote geologic past in the roots or leaves of plants now living. In the principles of the recapitulation, reversion and retention of ancestral characters, we have as it were the three fundamental R's of morphological science, by the aid of which we are now for the first time in the position to begin the construction of a natural system.

3. *Ecology:* ARTHUR HOLLICK.

Plant ecology is that branch of botany which comprises the study of the interrelations of plants and their relations to environment. As a distinct science it is practically a product of the present generation, and the term has only been recognized in common usage within the past twenty-five years or so.

The relation of paleobotany to botany, in connection with ecology, is mostly concerned with the problems of phytogeography. Paleobotany has supplied the explanations of many puzzling facts in regard to endemic floras; the occurrence of some genus or species only in certain widely separated regions of the earth, and the geographic isolation or limitation of others. Most of the phenomena of plant distribution in general at the present time would have no logical or adequate explanation but for the facts which have been revealed by the study of fossil plants and their distribution in the past.

Among the many striking instances in such connection may be mentioned the explanations which paleobotany has given in regard to the endemic floras of Australia and other regions; the distribution of such genera as *Nelumbo* and *Liriodendron;* and the geographic isolation of *Sequoia, Taxodium, Ginkgo* and other genera.

In tracing the facts of the ancestry, former distribution and extinction of species and genera paleobotany has demonstrated that there is no necessity for invoking the aid of inadequate and unsatisfactory theories of migration in recent times, or the origin of a genus, *de novo,* in two widely separated regions, in order to account for some of the puzzling phenomena of modern phytogeography.

Following are abstracts of the papers presented at the scientific sessions:

The Connective between Conidia of Penicillium: CHARLES THOM, U. S. Department of Agriculture.

References to a "connective" (Brücke, Dis-

junktor, Zwischen-zelle) between the conidia in species of *Penicillium* are widely scattered through the literature. This was figured by Strasburger in "Zellbildung und Zelltheilung" (1879) and reappears in the latest discussion of the group by Westling (1911). The appearances described under these names are easily seen and commonly but by no means uniformly found in certain species. To discuss this the usual method of conidial formation must be briefly described. The spore-bearing cell (sterigma, basidium, conidiiferous cell) has a definite permanent length of fairly uniform diameter, then tapers into a tube of smaller diameter from which the conidia are abstracted. This fertile tube elongates rapidly during the growing period. The nucleus of the cell divides, one daughter nucleus migrates to the tip of the tube, a wall then cuts the new cell from the old. The newly formed conidium in every species so far carefully studied is cylindrical, and more or less quickly swells to assume the globose or elliptical form characteristic of the particular species. The cylindrical form is lost so quickly that many preparations will not show such conidia, especially where growth conditions are not especially favorable. Similarly the tube may be very short or 2 to 3 μ in length in the same preparation. As the conidia swell from the cylindrical to the elliptical or globose form the appearance described as a connective is obtained when the primary wall of the original tube fails to follow the change in form and leaves an open space between itself and the new walls of the adjacent conidia in the chain. This appearance is by no means uniform in any species examined, but admits of the same explanation in every case seen. Nuclei have been fixed and stained in but few of these forms.

Perennial Gametophytic and Sporophytic Generations in Puccinia obtegens (Lk.) Tul.: Edgar W. Olive, South Dakota State College of Agriculture and Mechanic Arts.

This brachyform of rust, better known under the name of *P. suaveolens*, grows at Brookings on an European variety of Canada thistle. As described by Rostrup and others, it is said to possess two distinct generations: one resulting from a general infection throughout the whole plant, in which the characteristic, sweet-smelling pycnidia are shortly followed by large, confluent sori of uredospores, among which are later developed a few teleutospores; and, second, a strictly local infection, in which only uredo- and teleutospores are produced and borne in small, scattered sori.

Some preliminary cytological investigations of the so-called first generation show that both uninucleated gametophytic and binucleated sporophytic mycelia ramify together throughout the infected plants. The uninucleated mycelium produces the pycnidia; and is present also at the base of the uredo-sori. But the binucleated mycelium also invades the uredo-sori and these sporophytic hyphæ alone apparently produce the uredospores, which therefore should be regarded as secondary in their nature. Primary uredospores, produced by sexual fusions, were not observed. Teleutospores also arose from the same sporophytic mycelium.

The general infection of the Canada thistle is therefore due to the growth of two generations: a mixture of gametophytic as well as sporophytic mycelia; and the evidence appears to show further that both uninucleate and binucleate mycelia winter-over together in this mingled state in the underground parts of the plant.

A Revision of the North American Species of Puccina on Carex: Frank D. Kern and Mary A. Fitch, Purdue University.

Although there has been an accumulation of considerable information concerning the North American sedge rusts most mycologists have regarded this group as especially difficult. This is perhaps due to the fact that the telia do not usually present diagnostic characters. In the separation of these species it has been necessary to look for other features, and, as has been the case in several other groups of the rusts, it has been found that the urediniospores have furnished especially good characters. The æcial connections as brought to light by cultures are also important. The presence of amphispores in some of these species and the splitting of other species into races lend biological interest to these studies. About twenty-five species of *Puccinia* on *Carex* can be recognized in North America, the majority being endemic. About three fifths of these have had their life-histories worked out.

Cultures of Uredineæ in 1911: J. C. Arthur, Purdue University.

The thirteenth year of culture work with plant rusts gave an unusual number of failures, largely ascribable to the unseasonable hot weather. Of the 193 available collections with resting spores, mostly on grasses and sedges, only 37 germinated, as proved by about 700 drop-culture tests. Out of the small number 14 infections were obtained, with 143 sowings. In addition to these 17 infections

were obtained from freshly gathered material of *Gymnosporangium*, *Peridermium* and *Æcidium*, out of 91 sowings.

The most important results of the year were (1) finding an æcial host for *Gymnosporangium speciosum* outside of the families Malaceæ and Rosaceæ, *i. e.*, on *Philadelphus*, belonging to the family Hydrangiaceæ, and (2) finding that both the *Uromyces* and *Puccinia* on *Distichlis spicata* produce indistinguishable æcia on the same æcial hosts. The latter result taken in connection with facts brought out in former culture work leads to the conclusion that in some cases at least forms placed in the two genera, *Uromyces* and *Puccinia*, are not worthy of generic difference, and scarcely entitled to specific difference. They more truly represent races, or possibly varieties, of one species, rather than two species belonging to two genera.

Plus and Minus Strains in an Ascomycete: C. W. EDGERTON, Louisiana Experiment Station.

A species of *Glomerella* collected on a petiole of a cottonwood leaf in Louisiana has been producing perithecia on culture media for nearly a year and a half. The original culture has been separated into two distinct strains, called Plus and Minus. The Plus strain develops mature perithecia in masses occasionally, these being identical with other species of *Glomerella*. The Minus strain develops the perithecia singly or in two's or three's over and in the medium, but these do not come to maturity except on certain media and then the asci are very ill-shaped. When the two strains are grown on the same plate, there is a boundary line, where they come in contact, of well-developed perithecia. There is a cross-fertilization between the two strains, as is shown by the fact that ascospores in the same perithecium develop both strains on culturing.

The Morphology of Zygorhyncus and its Relation to the Ascomycetes: GEO. F. ATKINSON, Cornell University.

In *Zygorhyncus* the fruiting hyphæ are aerial and arise from the submersed vegetative mycelium. The branching is sympodial, the first sporangium terminating the primary hypha, the system finally bearing several sporangia, the successive ones usually standing higher. The sporangial branches are often more or less spirally curved.

The branched gametophore is the morphological equivalent of the sporangiophore, and the sexual branches are morphologically equivalent to the sporangial branches, and arise according to the same plan. The gametophores and sporangiophores are usually pure, but sometimes mixed.

The first antheridial branch is terminal, and subtended by the oogonial branch. The latter curves around, is often spirally twisted, and comes in contact with the former, usually touching it on the side. The end of the oogonial branch then enlarges into an oval body and is divided by two cross walls. The terminal pointed cell in contact with the antheridium is the homologue of the ascomycete trichogyne, and the subterminal cell is the egg. The "zygospore" wall eventually includes the two cells.

The sexual apparatus of *Zygorhyncus* is of the same type, and may be regarded as representing the ancestral form of the same, in *Monascus, Gymnoascus, Pyronema*, etc., and the gametophore may be regarded as representing the ancestral form of the Laboulbeniales. It does not seem necessary, therefore, to derive the ascomycete thrichogyne from the Rhodophyceæ.

Development and Fertilization in Olpidiopsis: J. F. BARRETT, University of Illinois.

Three species of *Olpidiopsis* were included in this study: *O. Saprolegniæ* Cornu, on *Saprolegnia; O. vexans* nov. sp., on *Saprolegnia*, and *O. luxurians* nov. sp., on *Aphanomyces*.

Zoospores biciliate with the cilia of equal length and attached at or near the anterior end of the elongated body. Zoospores possess two motile stages separated by a brief period of rest, suggesting a primitive type of diplanetism. Individuality of the zoospore, after penetrating the host, is maintained throughout its development. Little if any amœboid movement.

Segmentation of the sporangial contents apparently simultaneous throughout. Zoospores on escaping contain vacuoles.

True sexuality probably exists, and takes place by the fusion of two sexually differentiated individuals and the subsequent passage of the protoplasm of the smaller, male, into the larger, female, cell. This is followed by a supposed fusion of nuclei.

Both sexual and asexual reproductive bodies develop rather rapidly from a uninucleate to a multinucleate condition. The oospore is likewise multinucleate.

External conditions play a great part in the determination of sex in these organisms. This fact adds evidence, it seems, to the doctrine that sex in many plants is determinable by external or nutritive conditions.

Nuclear division is mitotic with the nuclear spindle intranuclear.

Variations in Glomerella: C. L. Shear, U. S. Department of Agriculture.

The results are given of studies of various races, strains, varieties and species from forty-six different host plants. Variations in morphological characters of all kinds were observed. Great variations in physiological characters, such as virility, adaptability to various hosts and reaction to culture media, also occurred.

Numerous generations started from single ascospores and conidia were grown under the same conditions. Rather striking and sudden variations occurred in some of these cultures, also intergrading forms and variations appeared. The conidial generations showed greater variation than the ascospore generation. Most of the variations studied show no direct relation to the culture media or other conditions of environment. More or less distinct races or strains were found to occur on the same host. These strains maintained their principal characteristics in cultures as long as they were grown.

The Perfect Stage of the Rose Actinonema: F. A. Wolf, Alabama Experiment Station.

The fruit bodies of *Actinonema rosæ* are not pycnidia as in the Sphæropsidales, but acervuli as in the Melanconiales. Persoon, who described the genus *Actinonema* (''Mycol. Eur.,'' 1822) characterized it as having radiate, sterile, mycelial strands. Fries (''Summa veg. Scand.,'' 1849), whose characterizations Saccardo employs, describes the genus as having a fibrillose radiating mycelium, a delicate perithecium and bilocular spores. The genus *Marsonia,* whose conidia are similar to *Actinonema,* has a *subepidermal* acervulus. The acervulus of *Actinonema rosæ* is *subcuticular.* The rose fungus evidently possesses the characters of neither a typical *Marsonia* nor of an *Actinonema.*

Leaves affected with the conidial stage, when wintered out-of-doors, developed a microthyriaceous ascosporic stage. The shield and spores are like *Asterella.* These perithecia though consist of a *subcuticular* shield and an innate apothecium which are entirely separate in origin and open like the Phæcidiales. The Microthyriaceæ are *superficial* and with a well-developed structure *only on the upper side.* The type of development as exhibited in the rose fungus is not like *Asterella,* which has been made to include heterogeneous elements and so a new generic name, *Diplocarpon,* is proposed. This study connects for the first time the conidial and ascosporic stages of the organism causing the black spot of roses. The new name *Diplocarpon rosæ* is given to the fungus.

Infection Experiments with the Powdery Mildew of Wheat: George M. Reed, University of Missouri.

Experiments have been made in which eighty different varieties, belonging to nine different species of *Triticum,* were inoculated with conidia of *Erysiphe graminis* DC. occurring on wheat. By far the larger number of these varieties proved entirely susceptible to the fungus. Forty-eight varieties gave an infection of 100 per cent.; seventeen, an infection of 70 per cent. or higher; four, an infection of 50 to 70 per cent.; four, a low percentage of infection (4 to 27 per cent.); and seven proved practically immune to the mildew. In the case of some of the latter varieties an occasional partial infection was noted.

The seven immune varieties found belonged to two species (*Triticum dicoccum* and *Triticum vulgare*), five of these varieties belonging to the former and two to the latter species. The emmers, as a group, have proved to be quite free from infection, although some, as the Winter Emmer and Red Emmer, were entirely susceptible. It was noted that in every case the varieties which proved to be highly resistant to infection are spring varieties.

No one of the nine species of *Triticum* tested proved to be entirely immune. In every case one or more varieties belonging to each of the species gave infection.

The Organization of the Hymenium of the Hymenomycetes: A. H. Reginald Buller, University of Manitoba.

The Nature and Proper Treatment of Lichens: Bruce Fink, Miami University.

An outline of the discussion to appear in the second paper of the series on ''The Nature and Classification of Lichens'' now being published in *Mycologia.* A statement of the difficulties due to the traditions regarding lichens and the consequent inconsistent treatment of lichens by many botanists. A brief outline of the arguments for or against various ideas and hypotheses, especially those of de Bary, Schwendener, Reinke, Schneider, Peirce, Danilov, Elenkin, Famintzin, Bessey and Clements. A conclusion reached as to whether the lichen is a colony, a dual organism or a fungus. In conclusion, the fundamental problems regarding the proper treatment of lichens by morphologists,

taxonomists, physiologists and ecologists are discussed briefly.

The Deposition of Iron on the Mycelium of an Aquatic Fungus: GEORGE T. MOORE, Washington University.

An aquatic ascomycete having peculiar spine-bearing spores, which readily germinate, was described. The mycelium from the germinating spores soon becomes encrusted with iron in much the same way that the so-called "iron bacteria" are covered with a deposit of iron. The material was particularly favorable for demonstrating that the process of iron deposition was not a vital one, as has been supposed for the bacteria.

A New Wood-penetrating Alga: GEORGE T. MOORE, Washington University.

An unbranched filamentous alga, with affinities with the Cladophoraceæ was found penetrating the cells of a yellow pine board, which had been submerged in an aquarium for several years. The germination of the akinetes and peculiar habit of growth was described.

The Structure and Development of the Colony in Gonium: R. A. HARPER, Columbia University.

The 16-celled colonies of *Gonium* are formed from the mother-cell by definite mosaic development and are thus in sharp contrast with the colonies of *Hydrodictyon* or *Dictyostelium*. The mother-cell divides by three successive bi-partitions, the successive planes of division cutting each other at right angles. Each cell of the daughter colony occupies the same position in relation to its sister cells as it had in the undivided protoplasm of the mother-cell. The plane of the first division is apparently determined within the cell. The different cells of a mother colony divide at all angles with the plane of the colony as a whole. The changes of position and form which the cells of the daughter colonies undergo as they grow to mature size are apparently determined entirely by relations of adhesion, surface tension, etc. Only qualities of the cells as such appear to be transmitted; the organization of the colony as a whole is only indirectly represented in the mother-cell.

Some Physiological Conditions in the Culture of Spirogyra: W. D. HOYT, Rutgers College.

A large part of the trouble commonly experienced in growing algæ in the laboratory is probably due to the water used, since, in physiologically pure water, *Spirogyra* was kept in perfect condition for several months. The nutrient solutions of Sachs, Molisch, Knop and Crone were tried. The best growth was obtained in Crone's solution containing from 0.05 per cent. to 0.1 per cent. of total salts.

As has been shown by others, tap water and ordinary distilled water were highly toxic. The contained toxic substances were partially or wholly counteracted or removed by the addition of some, but not all, absorbing substances; by a high concentration of nutrient salts—0.5 per cent. to 1 per cent. of total salts; or by great heat. The results obtained indicate that the toxic bodies of tap water and distilled water were different substances; that those of tap water were, in part, volatile organic substances; and that those of distilled water were largely non-volatile inorganic substances.

A good growth was obtained only when a properly balanced solution containing all the nutrient salts was used, but the salts of any two of these metals gave a better growth than the salt of any one metal when used alone. No specific antagonistic action was observed—a mixture of magnesium and potassium salts seemed just as favorable as a mixture of magnesium and calcium salts.

A colloidal solution of silver was fatal in all concentrations as low as 0.0000045 per cent. and was injurious in concentrations as low as 0.000000225 per cent. The addition to the weaker silver solutions of a 0.05 per cent. concentration of Crone's solution or of animal carbon produced marked improvement in the solutions. A colloidal solution of gold was only slightly injurious at a concentration of 0.009 per cent., while a colloidal solution of platinum of a .0096 per cent. concentration was not only not injurious during a short time, but produced improvement in tap water, in a weak colloidal silver solution, and in a solution of magnesium sulphate.

When filaments of *Spirogyra* were placed in colloidal gold or platinum, to which was added about 0.015 per cent. NaOH, the outer layers of their walls swelled and formed gelatinous-looking sheaths which often broke off in crumpled masses. These sheaths were not formed in either the platinum solution alone or in the NaOH solution alone, but were formed when both NaOH and either gold or platinum were present. These sheaths were deeply colored by the gold and platinum, while the layers of the wall which formed no sheaths remained uncolored.

The Effect of Light on the Liberation of the Eggs and Spores of Dictyota dichotoma: W. D. HOYT, Rutgers College.

As the eggs of *Dictyota dichotoma* approach maturity, two layers can be distinguished in the walls of the oogonia, of which the inner becomes very thick as the egg ripens. In the discharge of the egg, the outer wall is burst, while the inner, still enclosing the egg, is protruded and is soon dissolved, freeing the egg and allowing it to round up. The outer layer of the oogonium wall then appears as a ruptured, crumpled membrane.

The discharge of the tetraspores was not observed, but probably occurs by the same mechanism since the young, mature and empty walls of the tetraspore mother cells show the same appearances as those described for the eggs.

Both at Naples and at Beaufort, North Carolina, the discharge of eggs in the laboratory began very early in the morning, when daylight was just visible or even, at times, before the slightest trace of light was discernible. At Beaufort, the time when this discharge commenced varied in different summers, and in the latter part of any one summer, but was fairly constant for the earlier months of each summer. Both at Beaufort and at Naples, about 70–80 per cent. of the eggs liberated in any one day were discharged within the first half hour and about 80–90 per cent. were discharged within the first hour. At Beaufort about 70–80 per cent. of the entire crop of eggs were thus liberated within a single hour of one day of each month.

Attempts to alter the time of the discharge by subjecting the plant to various conditions of light and darkness were effective only as they affected the healthy condition of the plant. The attempt to induce liberation at other times of the day by exposure to various degrees of light, or to alternating darkness and light, was entirely without success. Discharge occurred as abundantly in dishes covered with red and with blue glass as in dishes covered with white glass.

The tetraspores were liberated throughout the day, although the majority were discharged before 7:00 A.M. Attempts to alter their rate of discharge by exposure to various conditions of light and darkness gave no marked result.

The experiments indicate that the light rays affect the liberation of eggs and spores by their effect on the well-being of the plants, rather than by acting as a direct stimulus to the discharge of these cells.

Alternation of Generations in certain Florideæ: I. F. Lewis, Randolph-Macon College.

Species of several genera of Florideæ have been cultivated during the past two summers at Woods Hole. By using the method employed by Hoyt with *Dictyota* it has been found possible to rear to maturity sporelings of known origin. In this way it has been shown that in *Griffithsia Bornetiana* and in *Dasya elegans* tetraspores without exception gave rise to sexual plants, which in *Dasya* were mostly male, and in *Griffithsia* about half male and half female. In *Polysiphonia violacea* carpospores produced, also without exception, tetrasporic plants. Hundreds of cases were observed. The experiments cited may be regarded as proof of the assumption, on cytological grounds, that there is an alternation of sexual and asexual individuals in Florideæ producing both tetraspores and carpospores.

The Germination of the Spore of Nemalion multifidum: I. F. Lewis, Randolph-Macon College.

After being shed, and attaching themselves to some hard substratum, the spores of *Nemalion* remain without visible change save a slight increase in size for twelve to twenty-four hours. The center of the spore is occupied by the large chromatophore with its pyrenoid, the latter bearing a marked resemblance to a nucleus, but larger. The small nucleus lies to one side of the pyrenoid. The first sign of germination is the protrusion of a germ tube through the spore wall. Into this the pyrenoid passes, along with most of the protoplasm. The spore cavity is left nearly empty. The nucleus, lying at the base of the germ tube, divides in the manner described by Wolfe for the nuclei of vegetative cells. One of the resulting daughter nuclei passes into the germ tube, the other into the spore cavity, where it becomes closely appressed to the wall as a structureless mass. The number of chromosomes in the first and later divisions is probably 8. A cross wall separates the germ tube from the nearly empty spore body, the latter taking no further part in development and soon dissolving in the sea water. The germ tube continues to elongate, and its nucleus divides in the usual way. The pyrenoid divides at about the same time, and a second cross wall cuts the germ tube into two parts, each with nucleus, chromatophore and cytoplasm. The apical cell so formed grows in length and divides. Repetition of this process results in the formation of a monosiphonous filament.

Nuclear Division in Spirogyra setiformis: F. McAllister.

The first indication of nuclear division is the accumulation of protoplasm at the poles of the nucleus. Later the nucleole loses its regular outline and stainable material seems to be given off from it into the nuclear cavity. No spirem seems to be formed from the reticulum. When the nucleole is nearly or wholly disintegrated, fibers from the polar region enter the nucleus and at the same time all the stainable material contracts to form the equatorial plate. This now separates into two parts, which move to the poles as dense homogeneous masses. Vacuoles appear and ultimately the stainable material is uniformly distributed through the daughter nucleus as pale blue-staining bodies. Red-staining bodies appear. The blue-staining bodies lose their distinctness and part of them, at least, form a homogeneous blue-staining ground substance in which the several red, nucleole-like bodies are imbedded. This mass rounds up to form the nucleole of the resting nucleus. During nucleole formation a delicate reticulum has appeared.

The Effect of Gymnosporangium upon the Transpiration and Photosynthesis of Apple Leaves: HOWARD S. REED and J. S. COOLEY, Virginia Agricultural Experiment Station.

In connection with pathological studies, the authors made determinations upon water elimination and carbon-dioxide consumption of healthy and rusted apple leaves. The varieties of apple known as York Imperial and Ben Davis were used. Transpiration was measured on twigs on the trees and determined in grams per square centimeter per hour. An average of five tests on Ben Davis apple leaves showed that in rusted leaves the water elimination was 50 per cent. of that in healthy leaves on the same trees.

For determining the rate of photosynthesis Ganong's photosynthometers were used. Experiments were always run in duplicate, using healthy and diseased leaves. Results were expressed as cubic centimeters of CO_2 consumed per square centimeter per hour. The diseased leaves showed marked diminution in power to consume CO_2.

A Study of Protoplasmic Movements in Fungi: F. M. ANDREWS, Indiana University.

Very little work has been done on the subject of protoplasmic movements in fungi. This study was undertaken in Pfeffer's laboratory to ascertain if the few observations made were correct and to extend them.

The fungi used for this investigation were *Mucor stolonifer, M. mucedo* and *Phycomyces nitens.* They were grown in various nutrient media such as a 4 per cent. solution of cane sugar; in gelatine (generally 10 per cent.), plum juice and others.

In making these investigations it was first attempted to determine the nature of the protoplasmic movements in the fungal filaments as they occur under ordinary conditions. Secondly it was desired to ascertain the effect of external conditions in the streaming movements such as temperature, food, transpiration, osmosis, light, injury, etc.

The most favorable temperature for growth is from 23 degrees to 26 degrees for the plants used. Below the optimum sudden rise in temperature of a few degrees results in movement if the protoplasm is still or an acceleration where slow movement is already present if all the other conditions are perfect.

In most cases those nutrient media containing sugar of sufficient strength produced an active growth and filaments having a large diameter which was necessary for favorable study. The gelatine and plum juice media also produced actively growing and wide filaments. In some other media, as where the sugar was entirely absent, only feeble narrow filaments were found.

In actively streaming specimens dry air caused acceleration for a time and then cessation of movement. On using moist air immediately after movement recommenced.

Streaming can also be produced in the filaments of these plants by placing a solution of sugar about the filament. Streaming then begins and continues according to the strength of the solution for some time. If after stoppage of the movement fresh water is added, the movement recommences.

Light, while not so noticeable as the other factors mentioned, causes a slight acceleration of movement of the protoplasm after the plant has been darkened for a considerable time.

Also injury, if not too severe, may cause movements to begin. All the conditions here mentioned have no effect unless the protoplasm is in a condition for streaming.

A Method for Preparing Stained Cells in Toto for the Study of Karyokinesis: ALBERT MANN, U. S. Department of Agriculture.

A Comparison of the Somatic and the Reduction Divisions in Carex aquatilis: A. B. STOUT, New York Botanical Garden.

In *Carex aquatilis* the chromosomes can be identified as individuals in the resting nuclei in

root tips, tapetum and sporogenous tissue and they can be traced as separate individuals throughout the whole process of somatic cell division. They also maintain a serial order in which the chromosomes appear as individual spheroidal masses with a relative place relationship. This is most clearly in evidence during the prophases.

In the prophases of the reduction division, on the other hand, the chromosomes appear at synapsis as an extremely thin double thread which in the thick spirem stage again appears single. This is in marked contrast to the somatic prophases where the chromosomes maintain a separate individuality which can be traced. In the preparation for the reduction division the substance is spun out and the chromosomes are so closely connected end to end that they can not be identified as individual units. It would appear that in this condition the opportunity is given for mutual influence and exchange of substance between homologous pairs.

After the reduction division occurs the three nuclei which lie at the apex of the wedge-shaped spore mother cell divide, making six nuclei which then die and become flattened out against the wall. The wall of the spore mother cell functions as the wall of the microspore.

In the resting nuclei of the microspores the chromosomes appear again as separate individuals.

Precarious Tests for Chemotropism of Roots: F. C. Newcombe, University of Michigan.

There is probably no part of a plant so sensitive to so many external stimuli as the tip of the root. The root-tip will give tropic responses to gravitation, in many plants to light, to moisture, heat, chemicals, in many species to pressure, to wounds.

The author has found still another response—that to a water-imbibed body in a water-saturated atmosphere. A piece of wet filter paper or of unglazed porcelain attached to the sloping side of the root will call forth a negative curve even in a water-saturated atmosphere. This result may be due either to a disturbance of hydrostatic conditions within the cells of the root, or to the accumulation in the attached body of volatile excretions of the root. The possible excretions must be volatile; for repeated use on successive roots of the same bits of paper, without washing, leads to no greater response. Either of the two possibilities assumed above could be interpreted as effecting traumatropic curves.

This extreme sensitiveness of the root-tip shows how precarious are the results of authors who think to test the chemotropism of roots by applying to the tip bits of paper imbibed with chemicals.

The Nature of the Absorption and Tolerance of Plants in Bogs: Alfred Dachnowski, Ohio State University.

The considerations of the quantitative nature of habitat factors, which are rightfully desired as a basis for a theory of physiologically arid habitats, do not, however, render more clearly the nature of the absorption of plants in bogs and the nature of their tolerance to toxic substances in peat soils. The physico-chemical effects of toxic bodies are in part these: they reduce the available water content, and they act in varying degree directly upon the roots of plants and their functions. Since there are (under field and laboratory conditions) no differences in the evaporating power of the air, in temperature, in greater intensity of light, in the gradient of osmotic concentrations and in the possible rate of movement of water through the soil; and since no morphological limitations in the absorption and in the conduction of water (in the agricultural plants used) enter into the problem, the phenomena of absorption and of resistance to desiccation deal, plainly, with considerations of the permeability of the absorbing protoplasmic membrane, its power of endurance and its ability to transform the injurious bodies into insoluble, impermeable compounds. A study of the behavior of different species of cultivated plants and especially a number of their varieties forces the assumption that changes of a cytoplasmic nature are particularly important under the conditions of growth.

The Permeability of Protoplasm to Ions and the Theory of Antagonism: W. J. V. Osterhout, Harvard University.

Experiments were performed to test the electrical conductivity of living tissues in various solutions. The results show conclusively that a great variety of ions readily penetrate living cells and that antagonism between salts may be explained by the fact that they hinder or prevent each other from entering the protoplasm. The ions of NaCl readily penetrate the protoplasm, but the addition of a small quantity of $CaCl_2$ greatly hinders this penetration. Such salts as KCl, $MgCl_2$, CsCl, RbCl, LiCl, NH_4Cl, NaBr, NaI, $NaNO_3$, Na_2SO_4 and Na-acetate act in general like NaCl while $BaCl_2$ and $SrCl_2$ act like $CaCl_2$.

The mechanism of this action is not fully under-

stood, but it may be stated that $CaCl_2$, $BaCl_2$ and $SrCl_2$ bring about visible changes in the plasma membrane which are quite different from those produced by such salts as NaCl, and it is hoped that a further study of these visible changes may throw some light on this question.

Observations on Evaporation and Transpiration in Prairie and Forest: B. SHIMEK, Iowa State University.

In an effort to determine the differences between forest and prairie plants which would account for their distribution, observations were made on the transpiration of certain forest and prairie plants in their native habitats and in transposed habitats. To illustrate the plan and purpose of the work two sets of plants are taken. In one of these cases *Phryma leptostachya* L. from the forest and *Kuhnia eupatoroides* var. *corymbulosa* T. & G. from the prairie were compared, and in the other *Anemone virginiana* L. from the forest and *Verbena stricta* Vent. from the prairie were employed for the same purpose.

Two stations were selected on a ridge near Iowa City, one side of which is prairie and the other forest, one station being located in each. The plants, which were as nearly as possible equal in size and vigor, were cut and inserted into bottles of water, which were sealed. Two plants, one from the forest and one from the prairie, were placed at each station, and the loss of water was determined at two-hour intervals.

In addition to this, observations were made at each of the stations on evaporation, and the meteorological conditions affecting it. The latter observations showed substantially the same relative results for prairie and forest as those previously published by the writer.

The results may be briefly summarized as follows:

The *Phryma* in the forest lost 1.9 gram, while that on the prairie lost 4.65 grams. The latter transpired very actively until it began to wilt, and then transpiration declined very rapidly, the plant soon becoming dry and crisp. The *Phryma* in the woods scarcely showed signs of wilting.

The *Kuhnia* in the forest lost 7.16 grams and remained perfectly fresh. That on the prairie lost 11.13 grams, and was also fresh at the close of the experiment. The diminution in transpiration in the forest was probably due in part to diminished activity on account of less intense light.

The *Anemone* lost 3 grams in the woods and 4.89 grams on the prairie.

The *Verbena* lost 6.58 grams in the woods and 27.4 grams on the prairie, transpiration in the woods declining in mid-day, being greater at both extremes of the day. The decline on the prairie in both cases was uniformly quite rapid. The greatest transpiration occurred in all cases just before wilting began.

The general result shows that transpiration and evaporation are not coincident.

Shade as a Factor Influencing Evaporation: G. P. BURNS, University of Vermont.

There is a general belief among some ecologists that the evaporating power of the air is the most satisfactory summation of the atmospheric factors controlling plant distribution.

In forest nurseries it is the usual practise to grow young pine trees in beds covered with racks whose sides are either wood or heavy paper and whose top is covered with lath. Every other lath is nailed, the free lath being later removed to produce "half-shade."

During the summer a study of the condition in the seed-beds has been carried on. The results as shown by the Livingston atmometer are given below.

Numerous stations were established representing all of the conditions found in nursery practise and in the adjacent forest areas. The control station was located in the nursery in a very large wire cage. The average amounts of daily evaporation from the various stations were as follows: control 45 c.c.; full-shade 19 c.c.; half-shade with solid sides 20 c.c.; half-shade with wire sides 43 c.c.; pine woods 16 c.c. Of these amounts from 17 per cent. to 25 per cent. is lost during the twelve hours 6 P.M.–6 A.M., the remainder during the time between 6 A.M. and 6 P.M.

The data gathered seem to show that the shading of young trees is a matter of evaporation rather than a matter of light, as is generally stated in the literature. The final word, however, must be spoken as a result of experiment.

The Investigation of a Climatic Gradient: FORREST SHREVE, Carnegie Institution.

The Santa Catalina mountains, in southern Arizona, rise from the desert plain at 3,000 feet altitude to a height of 9,100 feet. The lower slopes are characterized by desert vegetation, the middle altitudes by chaparral, the higher by coniferous forest. The influence of slope-exposure is such as to make the vertical limits of these zones and their component plants about 1,000 feet higher on

south-facing than on north-facing slopes. Instrumentation has been carried on at six stations, separated by vertical intervals of 1,000 feet. The data have furnished curves showing the altitudinal change of temperature, rainfall, soil moisture, humidity, evaporation and soil temperature. Mensuration has been carried on to determine the density and volume of the stands of characteristic trees at the different altitudes. Ratios of soil moisture to evaporation have been worked out from the instrumental data, showing the conditions which control the water intake and water loss of plants to be nine times as severe at 3,000 feet as at 8,000. The duration of the most critical season, as respects the water relation, is three times as long at 3,000 feet as at 8,000, making the desert conditions actually twenty-seven times as severe as those of the forested summits. The factors of soil moisture supply and atmospheric aridity, modified by slope-exposure, determine the lower limits of forest and the trees of the chaparral zone. The factors of winter cold, modified by topography through the operation of cold-air drainage, determine the upper limits of the characteristic desert species.

A Possible Mutant of the Sugar Maple: A. F. Blakeslee, Connecticut Agricultural College.

A single tree discovered in a roadside row of sugar maples is distinguished from the normal type by its peculiar habit of growth. The limbs are slender and branch profusely to form a close thicket of slender branchlets which end at a uniform distance from the trunk and produce an appearance similar to that of a symmetrical arbor vitæ.

A Balancing Method for Differentiating between Absorption and Transpiration: Lyman J. Briggs and H. L. Shantz, U. S. Department of Agriculture.

In this method the potted plant is suspended upon knife-edges in a horizontal position, so that the soil part of the system is on one side of the knife-edge and the plant on the other. The system is balanced by counter-weights, and a center of gravity so adjusted as to secure the required sensibility. As water is lost through transpiration, the soil end of the system becomes lighter and rises in consequence. If the moisture content of the plant has not changed during this process, the system will be restored to its zero position by the addition to the soil centroid of a weight equal to the total loss of water from the plant during the observation period. If the weight which must be added to the soil centroid to balance the system is less than the total loss of weight during the period, then the amount absorbed by the plant has been less than the amount transpired. If the weight required to restore the balance is greater than the loss in weight of the system, then the absorption during the period has exceeded the transpiration.

If the distances of the soil and plant centroids from the axis are known, the difference between transpiration and absorption during any period can be quantitatively determined. The location of the soil centroid can be found by observing the loss of weight, after the plant has been kept for a time under uniform conditions, so that the transpiration is equal to the absorption for the observed period. The plant centroid is determined from measurements of the area and the distance of the leaves from the axis.

This method is also adapted to the determination of the wilting coefficient for plants, which, owing to structural peculiarities, do not wilt when the moisture content of the leaves is reduced.

The Application of Wilting Coefficient Determinations to Field Work in Ecology and Phytogeography: Lyman J. Briggs and H. L. Shantz, U. S. Department of Agriculture.

The wilting coefficient is defined as the moisture content of the soil (expressed as a percentage of the dry weight) at the time when the leaves of the plant growing in that soil first undergo a permanent reduction in the moisture content as the result of a deficiency in the soil moisture supply.

The results of 1,300 determinations have shown that species differ only slightly in their wilting coefficients when grown in the *same* soil. The type of soil has a great influence upon the wilting coefficient, which ranges from less than 1 per cent. in sand to over 30 per cent. in the heaviest type of clay. It is therefore evident that soil moisture determinations for the purpose of establishing available moisture in the soil are valueless unless the wilting coefficient of the same sample used in the moisture determination is also known.

The desirability of a rapid determination of the wilting coefficient of samples taken in connection with field work led to an investigation to determine whether it could be computed from physical measurements of the moisture retentivity of the soil. Several methods have been developed, the relationships established being expressed in the following equations:

$$\text{Wilting coefficient} = \frac{\text{Moisture equivalent}}{1.84\ (1 \pm 0.007)}$$

$$\text{Wilting coefficient} = \frac{\text{Hygroscopic coefficient}}{0.68\ (1 \pm 0.018)}$$

$$\text{Wilting coefficient} = \frac{\text{Moisture-holding capacity} - 21}{2.90\ (1 \pm 0.021)}$$

$$\text{Wilting coefficient} = \frac{0.01\ \text{sand} + 0.12\ \text{silt} + 0.57\ \text{clay}}{(1 \pm 0.025)}$$

Inhibiting Factors in Lychnis and Papaver: GEORGE HARRISON SHULL, Carnegie Institution.

A cross between white-flowered and purple-flowered forms of *Lychnis dioica* L. (*Melandrium album* and *M. rubrum*), both from Germany, have given an F_1 predominantly white-flowered, though numerous previous crosses between other white-flowered and purple-flowered strains of this species have invariably produced only purple-flowered offspring in the F_1. The white-flowered form from Germany, in crosses with a "recessive white" American strain, produced in one case a white-flowered F_1, in another case a purple-flowered F_1. In *Papaver Rhœas* white has usually proved to be recessive to colors, but in one instance a cross between deep red and white produced a completely whitish progeny in the F_1, and the same result was also attained in a cross between two deep red parents. The latter experience suggests the existence of two complementary inhibiting factors, *A* and *B*, which have no effect except when coexisting in the same plant.

Inheritance in Capsella: H. HUS, University of Michigan.

Seedlings from a single plant of *Capsella Bursa-pastoris* can be classed in three groups: broad-leaved, narrow-leaved and linear-leaved. These forms occur approximately in the proportion 2:2:1. This proportion, which has been maintained for three generations, may perhaps be looked upon as a simple Mendelian splitting in the F_2 generation, of the *Zea* type, complicated by a defective inheritance ratio. This contention meets with the objection that the linear-leaved form represents a type thus far unreported.

The Origin of the Erect Cells in the Phloem of Abietineæ: M. A. CHRYSLER, University of Maine.

If a medullary ray in such a genus as *Pinus* is traced outward from xylem to phloem, it is well known that the marginal tracheids of the woody part of the ray may be seen to be replaced in the phloem by nucleated cells which are somewhat elongated in the longitudinal direction, the so-called "erect cells" of the ray. From a study of the roots of seedlings it is found that various transitions between these erect cells and sieve-tubes occur. Groups of elongated cells provided with nuclei and sieve-plates are a common feature of the phloem of these young roots, and where such a group meets a medullary ray certain of the elongated cells become applied to the ray and become progressively shorter, forming the erect marginal cells, while the rest of the elongated cells give place to ordinary sieve-tubes. Thus from what may be called *primitive sieve-cells* the sieve-tubes are derived by elongation, and the erect cells of the ray by shortening.

Do the Abietineæ extend to the Carboniferous? R. B. THOMSON and A. E. ALLIN, Toronto University.

The claims for the great geological age of the Abietineæ (see Jeffrey and Chrysler, *Bot. Gaz.*, p. 13, 1906) are based on the occurrence of *Pityoxylon chasense* in the Permian and on the supposed occurrence of *P. Conwentzianum* in the Carboniferous.

P. chasense was described by Penhallow in 1900. The pitting of the tracheids is of the Araucarian or Cordaitean type (1–3 seriate, alternate and hexagonal) and bears not the slightest resemblance to that of *Pityoxylon* as defined by Kraus (one-seriate, or opposite when two-seriate), or to that of an Abietinean form. Penhallow, however, placed this form in the genus *Pityoxylon* because of the occurrence of what he supposed were horizontal resin canals. A careful study of the type material has revealed that they are not resin canals but leaf traces quite comparable to those in certain Cordaiteæ and Araucarineæ. This Permian *Pityoxylon* is, therefore, a true Cordaitean or Araucarian.

Gothan has recently shown that *P. Conwentzianum*, which is commonly attributed to the Carboniferous but whose horizon was never determined, can not be an authentic Carboniferous form.

The geological claim for the great antiquity of the Abietineæ thus fails on critical study of the two forms upon which it is based.

Ingrowing Sprouts of Solanum tuberosum: C. STUART GAGER, Brooklyn Botanic Garden.

The paper described a case in which the sprouts of a large number of potatoes grew into and through the tubers that bore them, ramifying

freely and producing roots and small tubers within the large seed tuber. The potatoes were stored in a dry room lighted with diffuse daylight. Sprouts of one tuber never penetrated an adjacent one. Investigation failed to show the presence of any enzymes by the action of which the channels of the ingrowing sprouts could have been digested, though the epidermis of the sprouts was modified so as to resemble typical glandular epithelium, thus suggesting secretion. There was positive evidence that the sprouts made their way through the tissue by mechanical pressure. Attempts experimentally to produce penetration of tubers by potato sprouts met with success, except that the sprouts were unable to penetrate through the epidermis from the outside. These experiments, in connection with the behavior of the original abnormality, led to the high probability of a reversal of polarity in the shoots. The cause of tuber-formation in general was briefly discussed, as was also the bearing of the ingrowing sprouts on the question of the mode of emergence of lateral roots.

The Gametophytes of the Kauri: Arthur J. Eames, Harvard University.

The microspore contains many supernumerary prothalial nuclei. Its branching tubes penetrate the scale-base and the axis, thence crossing the space to the nucellus which is largely eroded, with portions of the endosperm. The megaspore, developing at first within "spongy-tissue," forms a club-shaped embryo-sac, bearing 6–20 archegonia. A small ephemeral ventral canal nucleus is cut off. Fertilization occurs usually in lower archegonia, the two large male nuclei being shunted from the upper egg-cells by a cap of the megaspore membrane which is thickened rather than thin as in most conifers. The pro-embryo maintains a central position in the archegonium in contrast to the condition in other groups until at least 32 nuclei are formed. Then nuclear enlargement and wall-formation ensue, filling the archegonium. The upper 20 or more cells become suspensors, the central group, consisting of a few cells, the embryo proper, and the basal tier a marked protective cap. The large core of suspensors thrust down the two lower tiers deep into the endosperm, where in further development the cap is pushed aside and degenerates.

The Gametophytes of Australasian Podocarps: Edmund W. Sinnott, Harvard University.

The gametophytes and embryo of *Podocarpus Totara, Hallii, nivalis, dacrydioides, spicatus* and *ferrugineus* have been investigated. Observations on the male gametophyte add to previous accounts, but agree in general with them. In the first four species (*Podocarpus* proper) three or four months elapse between the appearance of the megasporangium and the ripening of the fruit, and the development of the endosperm, archegonia, and embryo is much as in the Abietineæ. In all species, even a ventral-canal nucleus is uncommon. There are from eight to sixteen suspensors. The last two species (subgenus *Prumnopitys*) are very distinct. The reproductive process extends over sixteen months. The two very large archegonia are narrowed at the base. The fusion nucleus divides into four as it drops and the eight subsequent basal nuclei are irregularly arranged, as are the sixteen cells which follow them. The young embryo has a "penetrating cap." Both species of the subgenus *Prumnopitys* show a marked resemblance to *Cephalotaxus,* and further investigation promises interesting results as to the relationship of the two genera.

The following list of papers, from members of the society, or members of Section G, to be introduced by members of the Botanical Society of America, were received too late to be included in the printed program and were read by title:

Acidity as a Factor in Plant Ecology: F. V. Coville, U. S. Department of Agriculture.

The Cultivation of Trailing Arbutus: F. V. Coville, U. S. Department of Agriculture.

Ecology as Applied to the Revegetation of Overgrazed Range Lands: A. W. Sampson, U. S. Department of Agriculture.

The Relation of Soil Acidity to Plant Societies: A. W. Sampson, U. S. Department of Agriculture.

The Effect of a 2 per cent. Aqueous Solution of Antipyrin on the Cells of the Root-tip of Vicia faba: C. F. Hottes, University of Illinois.

On the Acidity of Certain Cacti: H. M. Richards, Columbia University.

Conditions Affecting the Production of Lycopin in the Tomato: B. M. Duggar, Cornell University.

Senility in Meristematic Tissue: H. M. Benedict, University of Cincinnati.

A Botanical Survey of Hartsville, S. C.: W. C. Coker, University of North Carolina.

The Biology of the Lakes of Glacier: M. J. Elrod, University of Montana.

The Cytology of Laboulbenia chartophora: J. H. Faull, University of Toronto.

George T. Moore,
Secretary